THE RAILWAYS OF GREAT BRITAIN

LORD MONKSWELL

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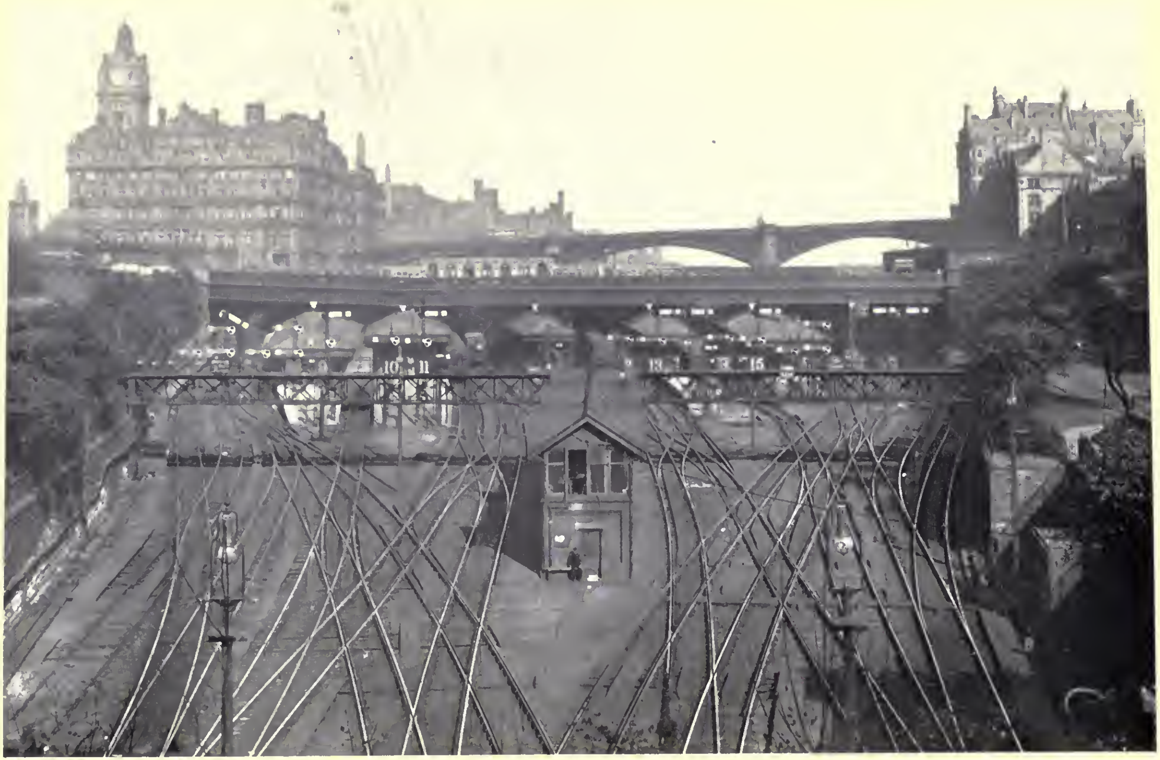
[*Frontispiece.*



WAVERLEY STATION, EDINBURGH

THE RAILWAYS OF GREAT BRITAIN

BY

LORD MONKSWELL

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ILLUSTRATED

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PREFACE

I HAVE to express my most sincere acknowledgments to a great many gentlemen connected with various British railways, and with the Chemin de fer du Nord in France, for the help which they kindly gave me, either by showing me things personally, or by giving me facilities of different kinds, or by supplying photographs.

M.

August, 1913

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RAILWAYS OF GREAT BRITAIN

CHAPTER I

THE EAST COAST

The recent formation of Railway Alliances—East Coast Route—North Eastern Railway—Competition—State Railways—Railway Servants—The Engines of the Great Northern Railway—Railway Carriages.

As a result of the seeking after economy which has imposed itself of late on the railways, a series of alliances to last for long periods has been made between the different companies, which has made impossible any fresh outburst of competition between the partners in the same alliance for traffic between the same places. So far as the public are concerned England, outside the district of the North Eastern Railway, which is not a partner in any alliance, is already practically divided up between four * groups of railway companies, and the possibilities of competition of such kinds as have up to the present existed are thereby much diminished.

* There is no definite alliance between the South Eastern and the Brighton Railway, but the traffic arrangements between them are sufficiently elaborate practically to constitute a tacit alliance. The other groups are (1) London and North Western, Midland, and Lancashire and Yorkshire; (2) Great Central, Great Eastern, and Great Northern; (3) Great Western and London and South Western.

So far none of the companies which form the East Coast and West Coast routes to Scotland has entered into a definite alliance with a company belonging to the opposite group, and competition between the two routes, though it is now held in check by a stringent agreement, might at any moment break out. In any case the interest which each of the companies concerned has in maintaining the existing arrangements is probably great enough to prevent any one of them from taking any step which would lead to an alteration in the routes taken by the trains which now leave the Great Northern and the London and North Western termini in London for Scotland.

On the West Coast route the territory of the two participating companies is sharply divided at Carlisle, and each company works all the traffic over the whole of its own road, but on the East Coast route the division of lines and the working arrangements are of some complication. For 160 miles out of London the line belongs to the Great Northern Railway; but it is not found convenient to stop all the trains at a point near where the Great Northern Railway ends and the North Eastern Railway begins, so most of the expresses are hauled as far as York—188 miles—by Great Northern engines. On to Berwick ($335\frac{1}{2}$ miles from London) the line belongs to the North Eastern, and the remaining $57\frac{1}{2}$ miles to Edinburgh to the North British. But, instead of handing the trains on to North British engines at Berwick, the North Eastern engines work the whole way through to Edinburgh. In the $130\frac{1}{2}$ miles hence to Aberdeen, where the traffic is worked by North British engines, the Forth Bridge, which is the joint property of four railway companies, is traversed; further on a section of the line belongs to the North British and Caledonian Railways jointly, and the last $38\frac{1}{4}$ miles from Kinnaber Junction are run over the line of the Caledonian. There does not on the face of it seem to be much reason why North Eastern engines should run the East Coast trains, including those which stop at Berwick, over the North British Railway between Edinburgh and Berwick, but the North Eastern appears to like sending its engines to Edinburgh, and at one time even had considerable litigation with the North British in order to endeavour to secure the right to continue doing so, which the latter company had refused any longer to recognise. During this period the usually slow-running North British engines were suddenly called upon to bestir themselves in a way almost unknown upon that railway where, on the other sections, the natural obstacles are so numerous and so great. The North British found itself obliged, in order to keep time with one or two trains, which otherwise would not have stopped at Berwick, to cover the $57\frac{1}{2}$ miles thence to Edinburgh in about an hour. The road is an easy one; for most of the first 16 miles, it is true, the line rises at about 1 in 200, but after this there are no difficulties worth mentioning. The North British Railway, being in a sort of way bound in honour to lose no time on this run, generally, if not always, used two engines, and had no difficulty in keeping time under all conditions. I travelled one night by the 11.30 from King's Cross while this system of working was in force. The North Eastern saved several minutes on the run from Newcastle to Berwick, where we stayed 7 minutes; then, starting off again from Berwick, behind two North

British 6 ft. 6 in. bogie engines, we reached Edinburgh in 59 minutes—well before time. The whole run from Newcastle, Berwick stop and all, took just the same time as the fastest non-stop run between the two points takes to-day. And this was in 1897.

Before the Tay and Forth Bridges, and particularly the latter, were built, the North British was a rather scattered railway; but, now that these bridges give direct access to Perth and Aberdeen, the system radiates most conveniently from its centre in Edinburgh, whence two long arms stretch north and south to Aberdeen and Carlisle, and two shorter arms east and west to Berwick and Glasgow. With the extra traffic brought by the Forth Bridge the already conspicuously inadequate accommodation in Edinburgh became more glaringly insufficient. Waverley Station in a press of traffic had for years, according to everyone who has ever written on the subject, been the place of all others where the nearest approach could be found to complete pandemonium. My own acquaintance with the old station was of the slightest, but the hideous inconvenience of the place could not fail to strike the most casual observer. This state of affairs at the very heart and centre of the system made the North British trains a by-word for unpunctuality, and it became necessary to remedy matters, however great the cost. Any one going to Waverley now, and having in mind what things used to be like, will give the North British all the praise it deserves for the admirable manner in which, with all the difficulties to face, which are inseparable from rebuilding operations on a very large scale, in the centre of a busy city, it has evolved order out of chaos, and constructed a station really worthy

THE FORTH BRIDGE.

of the importance of its position. Even now, however, at really busy times it is not always quite so easy as is desirable to ascertain at which platform some particular train may be found.

The opening of the Forth and Tay Bridges and the rebuilding of Waverley Station were steps which could not fail to produce immediately satisfactory effects. The other great new enterprise of the North British Railway—the construction, technically not by the North British itself, but by a company in close alliance with it, of the West Highland Railway—was of a much more speculative character. The construction of the West Highland Line seems to have been prompted by a desire to enter country which had, up to that time, been regarded more or less as a preserve of the Caledonian, if such a term can be applied to country so sparsely populated. The Caledonian had its Callander and Oban line connecting the West Coast with the populous central district of Scotland. It is improbable that the Callander and Oban has ever been a very profitable line. To push another railway into this inhospitable, if beautiful, district was a bold undertaking indeed. As there are no big works and no particular trouble seems to have been taken to avoid heavy gradients and sharp curves, the line cannot have been expensive to build, it is true, but a survey of the country, either on the map or from the carriage windows, inspires questionings as to how enough traffic is provided to make these 140 odd miles of line from Craigendoran to Mallaig pay their way. The questionings become more insistent when it is remembered that for nine months of the year there are, beyond Arrochar and Tarbet station—*i.e.* over more than 120 miles of the line—only two passenger trains a day. Up to this point, which the railway company appears to regard as the limit of what may be called the suburban district, the trains are comparatively frequent. But a pretty close acquaintance with the traffic dealt with at Arrochar and Tarbet during the height of the tourist season leads me to suppose that even this favoured spot, which serves the two villages, and also secures such of the passing Loch Lomond and Loch Long excursionists as do not travel all the way by steamer, can hardly be a gold-mine for the railway. The opening of the West Highland Railway to Fort William led to quite an outburst of railway building in the West Highlands, the Caledonian seeking to consolidate its position by pushing north to Ballachulish, the West Highland itself being carried later to Mallaig, and the Invergarry and Fort Augustus Railway being built to connect the West Highland with Loch Ness. This was during the era when that species of competition was rife which led railways to seek to invade the districts of other railways, but now that this has been succeeded by an era of agreements it is likely to be many a long day before any more railways are built in the West Highlands. The Invergarry and Fort Augustus Railway indeed, having proved unable to pay its working expenses, was for a time abandoned altogether. There is, however, one short connecting link that is badly wanted to join the West Highland Railway to the Highland Railway. The two railways at one point lie fairly close to one another, and, if a line were built from somewhere about Tulloch on the West Highland to somewhere about Newtonmore on the Highland, the very serious difficulties, which now attend a progress across the Highlands east and west, would be greatly diminished.

The thick and thin opponents of competition would probably rely largely on the case of the North Eastern Railway to bear out their views. Here is a railway less exposed to competition than any other in England. Hardly any part of the district which the North Eastern serves, except its edges, can be reached by another route. Far the greater part of the North Eastern's revenues coming from goods and minerals, it is perhaps not surprising to find unusually perfect arrangements for the working of goods and mineral trains, so that on the North Eastern these trains earn much more each mile they run than is the case on any other big line. The North Eastern believes in the advantages of accurate knowledge in all matters pertaining to the traffic, and it is known to compile very elaborate statistics, which enable it to see whether the results which are achieved are satisfactory, and indicates the lines on which further economies should be sought. But, far from the energies of the North Eastern Railway being exhausted with matters affecting the carriage of goods and minerals, there is no railway in England which in recent years has shown itself more receptive of new ideas or more anxious to introduce improvements of all kinds made available by the increase of technical knowledge. Whether in employing road motors to collect passengers and produce to feed the railway, in introducing electric working on the suburban lines round Newcastle, or in laying down water troughs and building the new King Edward Bridge over the Tyne to facilitate the working of its main line, the enterprise of the North Eastern has been remarkable. And though the dead weight of the agreement which forbids the East Coast companies to reach Edinburgh in less than $7\frac{3}{4}$ hours from London prevents the regular East Coast trains from attaining any great pace, the performances of some of the North Eastern trains, which are not hindered in this manner, are in a class altogether above those of ordinary British expresses. For some years now the North Eastern has run a train daily from Darlington to York—44 miles—in 43 minutes, while the train running in the opposite direction, which covers the $80\frac{1}{2}$ miles from York to Newcastle in 84 minutes, is nearly as good. (It used, however, to be 2 minutes faster than it is now.) Neither is it on the main line alone that the North Eastern service is good, the best Leeds and Scarborough trains in summer being equal, if not superior, to any seaside trains in the country. Indeed, the thing that hinders the East Coast express trains on the North Eastern from being much better than they are would appear to be the existence of a competing route, which in theory is the very thing that should supply a stimulus to increased exertions. The North Eastern is understood to be less attached to the agreement, which forbids the acceleration of the Scottish trains, than are the other companies which are parties to it. The weakness of the position of a railway, which deliberately refrains from offering the travelling public facilities, which it could very easily offer, does not appear altogether to have escaped the managers of the North Eastern.

At the present time when agreements and amalgamations, not only among railways, but in many other big businesses, are the order of the day, people are apt to condemn competition altogether, and to lose sight

KING EDWARD BRIDGE, NEWCASTLE.

of its obvious advantages; and the case of the North Eastern is certainly not specially calculated to show up these advantages. If, however, the matter is looked at closely, the out-and-out condemnation of competition appears to be quite as bad a mistake as is the exactly opposite attitude. Competition, when it really exists in what may be called a free state—*i.e.* unhampered by limiting conditions, explicitly or tacitly arranged between the competing parties—undoubtedly stimulates the spirit of enterprise, and tends to the introduction of all sorts of speculative improvements. Some of these may involve waste in the same way that a proportion of all enterprising speculations end in failure; but the public gain, due to the success of the remainder, which, but for competition would never have received a trial, may far more than compensate for the waste involved in the failures.

If competition of the narrow kind—that between comparatively small undertakings, situated close together, and competing for the traffic between the same places—is fast dying out, competition between the bigger and more powerful undertakings, by which the smaller ones are being replaced, as to which shall give the greater facilities, not so much to the same places, but to different places, situated in the respective districts of the different competitors, is likely to increase more and more. The railway facilities, which will be at a manufacturer's command, may well decide him whether he will set up his new works on the line of one company or another, just as the comparative merits of the Great Northern and North Western trains may cause holiday makers to prefer the coast of Lincolnshire or that of North Wales. And, if in time British railways all pass under one management, so that the element of competition is excluded from questions of this kind in turn, the amalgamated or nationalised railways will still find that there are a number of points at which they must strive to keep as much custom as possible for themselves, in competition with the attractions offered by the railways of the various continental countries.

Self-interest in some form or other is the power which drives along commercial undertakings like railways. For a railway, or any other business, to be run satisfactorily for its customers, it is desirable that the self-interest, which moves those who direct it, should be of as enlightened a type as possible. As, in the field of morals, it is often very difficult to fix the boundary line between enlightened self-interest and unselfish benevolence, so in commerce the concern which devotes the greatest energy to the service of its customers, is often found to be the most profitable to its owners. In a small business this fact is apparent, and makes itself felt automatically, but the conduct of a big business like a railway is so much complicated by the conditions under which it is carried on, that a full comprehension of the paramount importance of giving the best possible service does not impose itself in the same manner.

The system of management of British railways presents many points which are open to criticism. The shareholders, who are the actual owners and the people whom the financial results principally concern, must, from the nature of the case, delegate their powers of control to a committee. This committee is the Board of Directors, who are supposed to be elected by the shareholders. In point of fact, the Board, to all intents and purposes, elect themselves. The directors periodically retire by rotation, but it is the rarest thing in the world for any director, who offers himself for re-election, not to be re-elected by acclamation. If any director retires or dies the Board simply nominate his successor.

That the British railway shareholder is generally a patient and uncomplaining person cannot be doubted, and, when he desires to complain, the difficulties in the way of his doing so effectively are great. But, for all that, the bad times, from which the railways have suffered in recent years, have on various occasions roused the usually lethargic shareholders to something like active revolt against the Boards of Directors. Not so long ago the North Western Board found themselves engaged in a struggle of some duration with a body of shareholders who waged determined warfare upon them, and who, though not technically victorious, are believed to have inspired them with certain searchings of heart, which were by no means otherwise than tending to the more efficient conduct of the business of the line; and, before the financial results achieved by the South Eastern and Chatham Railway recently improved so much, the mutterings of a storm, which might burst in fury on the heads of the directors of that line, were distinctly audible from time to time. But, if the English shareholder has begun to make himself felt, it is the Scottish shareholder who showed him the way. Some years ago the North British shareholders practically turned out the whole of the Board of that railway at one swoop, and the action of the Association, which was formed by them and the shareholders of the other big Scottish lines, did something towards bringing about the working agreements which now exist between the Scottish railways.

In theory the Board of a railway consists of persons of good business ability, who, possessing the great advantage of wide experience in other matters besides railways, have at the same time enough special knowledge to have a definite opinion in all matters of policy, and to enable them to exercise effective control over the railway officers. Now this the Boards can hardly be expected to do when the circumstances are considered. There are, no doubt, a good number of first-rate men of business on the Boards of the different railways, but these gentlemen are nearly all notoriously engaged in other business pursuits, which must leave them little time which they can devote to the practically unpaid work of railway directing, and they are frequently deficient in special knowledge of railways. The consequence is that the officers, who really do devote their time to their work, and are adequately paid for so doing, find themselves—beyond having to keep within certain financial limits—subject to hardly any effective control, and have, as a rule, practically a free hand.

A railway, in fact, like any other big business, is not really managed by its proprietors, but by experts, who may, and very often do, have little or no pecuniary interest in it. And, however competent and broad-minded the experts may be, there is always at least the possibility that they will fail to appreciate the points of view of the shareholders and of the public.

As regards the public, their interests are to some extent safeguarded by the Government. Parliament has had to decide what conditions are most conducive to making the managers of railways devote as much energy and intelligence as possible to supplying the public with the best service. The theoretically possible conditions range from unlimited competition, without any State control, on the one hand, to a State monopoly on the other (the shareholders in this case being represented by the whole population). In practice, owing to the great expense of building a railway, and to the impossibility of recovering any appreciable amount of the capital sunk in a line which becomes derelict, competition between railways connecting the same places can never be in any true sense unlimited, and the greatest number of competitors that the richest traffic in the world could attract would be, perhaps, three or four, while, unless there is an assurance of a very considerable traffic, it is almost impossible to attract any competition at all. Then, even where this sort of competition theoretically exists, it is quite impossible to make the parties who should be competitors compete, if they do not consider that it is to their interest to do so. In this case, instead of competing, they enter into agreements with one another, whereby each one binds itself not to give more than such and such facilities to the public, and the result of this is that precisely those conditions are brought about which competition is intended to obviate. If no attempt is made to arrange for competition of some kind, the only ways in which anything can be done towards forcing railways to give proper facilities are to impose certain conditions upon them as a price of allowing them to come into existence, and to reserve for the State certain powers of control. This is always done, though the conditions imposed vary a great deal in different countries, and are always inadequate of themselves to secure the best results. The position comes to this: all railways—State owned or otherwise—have to submit to more or less stringent regulation in the interest of the public, and in some cases some form of competition—generally that more than one railway shall participate in the traffic between the same places—is also arranged, in the hope that this arrangement will act as a stimulus to efficiency. The question to decide is whether this competition—which is necessarily very imperfect because its intended effects can be evaded—does, or does not do, more good than harm. Experience has shown that in really important matters, such as rates and fares and speed of travel, railways are always very chary of competing with one another. If explicit agreements for obviating competition are made illegal, as in the United States, the railways have tacit understandings with one another, which cannot be put a stop to. In minor matters, on the other hand, such as the internal fittings of the trains, and the provision of meals *en route*, it is probable that competition has had some beneficial effect. The worst of understandings between railways is that they not only suppress competition for the time being, but act as a positive hindrance to the introduction of improvements, which might be expected to be made from time to time without the stimulus of competition. It is obvious that a railway manager is more likely to introduce an improvement if he has only the interest and convenience of his own line to consider, than if he has first also to enter into elaborate negotiations with a, possibly unsympathetic, rival. Moreover, the very fact of having a rival to consider tends to obscure the issue for him. If a great part of a railway manager's time is spent in arranging matters with a rival, the desirability of preventing his rival from passing him tends to assume in his mind an altogether exaggerated degree of importance, and he is but too likely to think that if he can keep pace with his rival all is well, and to ignore the fact that, by increasing the facilities offered to the public, he may, in any case, secure a handsome return, entirely apart from whether his rival does or does not also offer corresponding new facilities. So much for theory. Turning again to practice, if we compare the conditions in Great Britain with those in other countries, we are not much helped in any endeavour to decide whether or no such competition as has existed between different routes serving the same places has, on the whole, shown itself beneficial. At first sight it would appear that it has possessed certain advantages. It is found that in Great Britain, the only European country where different routes between the same important centres exist to any great extent under separate management, the train service is more complete than anywhere else, and faster than anywhere else except France, and the passenger fares are by no means particularly high. But when we remember that Great Britain was the first country to develop railways, and so got a long start of the rest of the world, and that the population of Great Britain for each unit of area is much greater than that of any other big country—more than twice as great as that of France, and half as great again as that of Germany—we see that there are other causes to which these effects may be ascribed.

No considerations of this kind, however, tend in any way to show that competition, if attainable, is incapable of producing good results on railways at the present time. Far from it—railways present so many possibilities of improvement that, if any really effective means could be discovered of inducing their managers to make bold experiments, it is more than likely that the best results would ensue. As has just been remarked, the facilities offered to passengers are certainly on the whole greater in Great Britain than elsewhere, and in conjunction with—probably in consequence of—this it is found that the passenger receipts per head of the population are approximately twice as large as they are in France or Germany.

On the face of it, then, there is very good reason for supposing that the receipts increase with the facilities offered. Now the two things, above all others, which passengers may be expected to care for, are reduced third-class fares and increased speeds. If railway managers, animated by some real spirit of competition, were to offer these advantages, it is possible, and even probable, that travel would increase so much that the railways, besides conferring a very great boon on their customers, would themselves secure large benefits.

As regards the goods traffic, the definite elimination of all competition would be likely to have the result of doing away with several very unsatisfactory features of this traffic. Even although there is ostensibly no competition in rates between the different companies serving the same points, there can be no doubt that the fear of losing traffic has frequently induced railways to make concessions of various kinds to traders, the results of which have been in effect to give more or less secret rebates to the traders in whose favour the concessions were made. There are so many services connected with the goods traffic, which the railways can perform, about which it is almost impossible to lay down any rule as to whether they are properly covered by the rate demanded, that it is extremely difficult for any outside person or authority to bring home to the railways any charge of undue preference with regard to them. Then a custom grew up, whereby the railways spent very large sums of money in providing warehouses, where the traders could store their goods for long periods, either free of charge, or, at least, without making any adequate payment. Sometimes, too, it is reported that for fear of offending a trader in a large way of business the railways would pay totally unjustifiable claims for compensation. In these ways competition must certainly be held to have existed, but competition of a most unsatisfactory nature, and calculated in many ways to give an unscrupulous trader advantages over his more scrupulous rival. Any combination among the railways, therefore, which tends to put a stop to practices of this sort, must be welcomed from the point of view of public morality. At the same time it must not be forgotten that there is another side to the question. Any one who has read the report on the Prussian State Railways, published a few years ago by the Board of Trade, will recognise that a pure monopoly has, under certain circumstances, power to safeguard itself in all its dealings with the public, in a manner of which we in this country are ignorant, and which no British trader would wish to see introduced. The danger of anything of this sort in Great Britain is, however, a very remote one.

The uneconomical manner in which some of the goods traffic has been conducted is illustrated by the important judicial decision, recently given in favour of the Scottish railways, which authorised them to charge demurrage and siding rent in a large number of cases upon rolling stock, which was withheld from circulation by the traders for an unreasonably long time. This shows how railway companies may benefit themselves by combined action. Owing, apparently, to absence of co-operation among the Scottish railways in former times, the traders had found themselves able, by playing one railway off against another, to detain rolling stock, without extra payment, for considerable periods, a proceeding which entailed much loss upon the railways, with, no doubt, some corresponding gain to the traders ; and this state of affairs had lasted so long that the latter held themselves aggrieved when at length the railways decided to insist upon payment, unless greater expedition were used. The expense of this greater expedition falling entirely upon the traders, while the railways were to secure the principal benefits, the traders found themselves in effect called upon to pay increased rates, a demand which they strenuously resisted till they lost their case in the courts.

Apart from the question of competition in the service which the companies offer to the public, there has in the past been very severe competition for the country which each line was to serve. There are only a few railway companies in Great Britain that have secured any considerable districts for themselves alone. From the very beginning the companies were encouraged to build rival lines between places of importance, and they continued to invade each other's territory at intervals, till, in many places where there is a large population, the lines belonging to the different companies form a perfect tangle. Each company has regarded it as pure gain to make its way to as many centres as possible, though, once there, its lust for aggression has ceased, and it has usually been willing to work in amity with its rivals. The most conspicuous instance, in recent years, of a long-established line invading a new district was when the Great Central built its new line to London, but that will probably be the last instance of the kind on so large a scale, as the companies have now generally come to the conclusion that the principle of territorial aggression is a mistake, and the aim of the closer understandings with one another, which have been entered into by so many of them, is in effect to divide the country into a certain number of districts which do not overlap—or overlap to a small extent only—and to leave a single management supreme in each district. It has already been pointed out that, owing to the much greater freedom of action which a single management enjoys, it is at least as likely as not that—in spite of the undoubted benefits which real competition, if attainable, is calculated to confer—an arrangement of this kind is in practice the more conducive to the benefit of the public, and, as the principle becomes more firmly established, it will be interesting to note its results.

In working a railway there are three parties concerned—the public, the shareholders, and the railway servants—and, for the best results to be secured, the interests of all three must receive due consideration. If, from one point of view, the interests of the three parties are divergent, and one may undoubtedly secure some temporary profit at the expense of the others, a broad consideration of all the facts shows that such a triumph brings with it no lasting gain, and that the interests of all three parties are really identical. If, for instance, rates and fares are made so low that the shareholders receive no dividends and the railway servants inadequate pay, then no more capital is forthcoming for developments, the railway servants do their work badly, and the service provided is in consequence certain to be a bad one. If too much is distributed in dividends to the shareholders, or if the railway servants receive excessive pay for performing an inadequate amount of work, analogous evils arise, which shortly affect that party also, which in the first instance profited at the expense of the others. It is, therefore, highly desirable for every one concerned that this community of interest should be recognised; and it is certainly a bad thing that any one of the three parties enumerated should be in a position to starve the others for its own supposed benefit.

So long as it is desired to preserve competition, or some semblance of competition, between railways in the same country, private ownership is a necessity, and the question of State ownership does not arise—at least not the question of the State ownership of all the railways. When, and if, it is definitely decided that competition is undesirable or unattainable, a new set of conditions are met with, and one of the barriers to State ownership has been removed.

Under State ownership the State takes the place, which, under private ownership, is held by the shareholders, and in theory there is no reason why State railways should not be worked on the same principles as railways owned by non-competitive private companies. One school of thought, indeed, which favours State ownership, does so on the ground that the railways would still be worked on commercial lines, only with greater economy and efficiency. This school may be called the commercial school. They see certain obvious causes of waste, which tend to increase the cost of privately owned railways, such as the existence of what they consider an unnecessarily large number of directors and high officials, and sometimes two trains running where one is enough. They think, perhaps, that rates are too high and that the energy of the companies is misdirected. They therefore favour State ownership because they see the advantages that would be possessed by a single administration in reducing waste and being able to direct its energies into the most economical channels, unhampered by competition. They may also think that a State department, being the servant of the whole nation, would be less avaricious and fairer in its charges than are private companies. But the views of this school would be almost as well met if the railways, instead of being taken over by the State, were united under a single private company, which would be bound to grant new facilities to the public every time it increased its dividends.

The political school of thought, on the other hand, which favours the nationalisation of railways, ranges from those persons who have a sentimental objection to the existence of any large monopoly in private hands, through the social reformers, who consider that the working classes do not receive a fair share of the good things of life, and that the existence of a large body of organised or organisable work-people, directly employed by the State, would be a convenient means of bringing to bear pressure towards effecting in a peaceful manner that redistribution of wealth which they desire, to the anarchists, who, working on the same lines as the social reformers, but with different ends in view, conceive that, under State ownership, the railway men might be easier to influence than they now are, and that a large and united body of Government servants, thoroughly aware of their power, might, if they could be worked up into a state of sufficient discontent, be very effective allies for the purpose of overthrowing all existing institutions. The aims, therefore, of all the people composing this class are essentially not economic aims; they have not necessarily any desire to increase the efficiency of railways as a means of transport, but, being dominated by ideas, the fulfilment of which they regard as of paramount importance, they wish to turn the railways to account in promoting their ideas, without in any way considering what the other effects of State ownership would be.

In theory, then, the commercial and political schools have nothing in common, though, as a matter of fact, the people who favour the nationalisation of railways are not sharply divided into one school or the other, but often look to securing greater economy and efficiency concurrently with the introduction of social reforms affecting the railway servants. This often really means that they hope to mix up business with philanthropy—a proceeding which, to say the least of it, is not likely to have good results. But, whatever the views may be of those people who desire the State ownership of railways, there can be no doubt at all as to the first result of such a reform, and that would be immensely to increase the power of the railway servants. As Government servants, all under one employer, they must be far easier to organise than they are at present, and the united pressure which they could exert on a Government department, by means of their voting power, must be immeasurably greater than the pressure which they can now exert upon the different companies, which are not amenable to direct pressure from votes at an election. Moreover, the officials of a Government department, because they are practically irremovable, would have even less direct interest in the finances than have the officials of a company, and must therefore have less desire to take the trouble to resist unreasonable demands on the part of the railway servants. If, then, the State were to take over the railways, the relative importance of the three parties interested in them—public, shareholders (*i.e.* State) and railway servants—would be greatly modified in the direction of giving more power to the last named, to which in practice the only check would be the force of public opinion. This force, useful enough as it is, makes itself felt but slowly, must always work more as a corrective than a preventive, of abuses, and would certainly be insufficient of itself to prevent the rise of the gravest abuses. Under these circumstances, to expect that the railway servants would not use their power to exact undue privileges for themselves would be to expect on their part a restraint uncommon, if not unknown, in public affairs on the part of any body of men whatever. If, therefore, the railways are ever taken over by the State, it is to be hoped that the question of disfranchising the railway servants will at the same time receive serious attention; unless they were disfranchised, there would be fear of developments, which would prejudicially affect every one who had to do with railways, not least the railway servants themselves.

In case the railways were nationalised, it is quite likely that some economy would be sought in reducing the salaries of the principal officers. It is probable that the principal officers of British railways at the present time receive salaries a good deal higher on an average than those paid to the principal officers of any State-owned railway on the Continent. The chief advantage of paying adequate salaries appears to be that it induces in the recipients a feeling of self-respect, and in their subordinates a tendency to look up to them, which might otherwise be absent. The reason sometimes put forward that good salaries attract the best brains, although superficially attractive, will hardly bear serious examination. Upon railway work practically every one enters in early youth, long before he can have formed any real estimate of his own abilities, and when the remote chance of eventually occupying one of the positions, to which fairly large salaries are attached, can scarcely be regarded as an inducement to adopt the profession. And, like many other occupations, the railway service does not offer any particular facilities for a specially good brain to make itself felt. Those fortunate persons who have made their way to the highest positions, would probably be the first to admit that their success has been due to a hundred accidents of influence or luck, and that for each possessor of a good brain who has reached a high position, there are a score of others, equally gifted, who have been left behind. It is probable that a reduction of the salaries attached to the principal positions would not mean that less capable men would be secured, but that these men would have less influence than is now the case.

To judge from some of the published speeches of the trade union leaders, a scheme which commends itself to the wilder section of these gentlemen's followers is that British railways should be taken over by the State, and "not run for profit." In this way it is suggested that means would be found for raising the wages and improving the conditions of the railway servants, while rates and fares could be lowered at the same time. The fact that the only possible ways of effecting such a change would be by depriving the present owners of the railways of their property without compensation, or by increasing the taxation of the country by not less than forty million pounds a year, or by some combination of the two methods, does not apparently cause the people who put forward these proposals the slightest misgiving. The advocacy of such schemes unfortunately shows that those who propose them are ignorant of, or indifferent to, what is possible. The existence of companies not amenable to direct political pressure must increase the difficulties of instituting wild experiments, which some political combination might endeavour to force upon the Government, and to this extent at least must be acceptable to reasonable people.

When considering the question of the possible nationalisation of British railways, we may glance at the results of the State ownership of railways in other countries. Most conspicuous among the State-owned lines of the Continent are those of Prussia. The Prussian Government owns all the important main lines in Prussia, and a very large proportion of the branch lines—it may, in fact, to all intents and purposes, be said to own the whole railway system. A fairly good service is provided and quite a good return is earned upon the capital invested in the railways. The conditions in Prussia are, however, peculiar. In the first place, the State ownership of the Prussian railways is intimately connected with the commercial policy of the German Empire, which seeks to foster German export trade, among other means, by very finely graduated preferential rates, which are carefully adjusted to the details of the German system of protection. Then, political dangers, due to the voting power of the railway servants, and to trade unionism, are, for various reasons, infinitely less formidable in Prussia than they would be in Great Britain. The Prussian Government, for instance, is not subject to Parliamentary control in the British sense; the railway servants, being reservists, can at any moment be subjected to military discipline; and membership of unauthorised trade unions is forbidden. One effect of State ownership is that, as the earnings of the railways form a very important part of the Prussian revenue, there is considerable reluctance on the part of the Government to spend money in building new lines anywhere where less than a normal profit would be likely to be earned, and so the development of the railways is certainly not more rapid than might be expected if they were in the hands of private companies.

In France, the original State railways were bought up by the Government more than thirty years ago. They run through comparatively poor districts, and the principal reason for their being taken over by the State appears to have been the difficulty of getting any one else to work them. Under these circumstances it is not surprising that they should not pay very well. Then, the Chemin de Fer de l'Ouest, which was taken over by the State quite recently, was the poorest of the great railway companies, and at the time when it was taken over, was in no way fitted to cope with the traffic passing over it, so that in this case also the State started heavily handicapped. It is to be noted, however, that the entry into possession by the State was closely followed by a long series of alarming and disastrous accidents, and that, at the time of the great French railway strike of 1910, this railway suffered much more severely than did some of the companies' lines.

In Italy, seven or eight years ago, the State took over the working of the railways, to find itself, so far as could be judged from the reports which reached this country, face to face with a state of practically open insubordination among the whole body of the railway servants, while the grossest abuses were rampant on every side, and lines and rolling stock were in a condition bordering on decay, and were entirely inadequate in quantity. Humorous descriptions of the Italian lines having lately become less frequent than they used to be in the newspapers, it is to be presumed that the Italian Government is gradually effecting improvements.

None of the foregoing cases present enough analogy to the circumstances which are likely to arise in connection with any probable scheme for the nationalisation of British railways to be of much value for purposes of comparison.

The great mass of British railway servants must be included in the category of only semi-skilled workers, and, as such, do not receive high pay. The railway service offers, indeed, the advantage of permanent employment—a man, so long as he behaves well, is extremely unlikely to be dismissed. But the existing conditions of service are naturally not sufficiently advantageous to produce a feeling of complete contentment with their lot among the whole body of railway servants. In recent years, beyond the general rise in prices, which reduces the purchasing power of wages, matters have no doubt got worse in another way, because, in consequence of the agitation against too long hours of work, railway servants now get fewer opportunities of working overtime than used to be the case, and their incomes are by so much reduced. Work on railways is often hard and exacting, and there is, no doubt, on the part of railway servants, who find their conditions of life unsatisfactory, a certain amount of that perfectly legitimate discontent, to which human progress is chiefly due. It would, perhaps, be too much to expect that such discontent as exists should make the men affected set to work along always logical and irreproachable lines to find a remedy. Some unwise agitation has certainly taken place, and very crude proposals have been made on the part of the men, who, in one way, are in a strong position as against the companies, because a strike on their part cannot possibly be met by a lock-out on the part of their employers.

In 1907 a certain unrest, which had for some time been apparent in the railway world, came to a head, and there were threats of a strike, which might perhaps have attained some magnitude. The exact degree of seriousness in the situation was a matter of great uncertainty. Some people thought that the situation was very serious indeed, and others were of opinion that no strike of any importance was in the least likely to occur. However that may be, the representatives of the companies and of the men each agreed to meet the Board of Trade officials, and an elaborate scheme of conciliation and arbitration was drawn up and accepted on the spot by all the big railways, except the North Eastern (which "recognised" the men's unions and had different arrangements). The servants of each company were divided into a number of classes, for each of which a Conciliation Board (composed of representatives of the company and of the men *) was appointed. These Boards were to endeavour to settle any dispute which might arise. If they failed to do so, the dispute was to be referred to a Central Board, representing the company and the whole of its servants. If, here again, no agreement was reached, the matter was to be referred to arbitration. A considerable number of claims were put forward by the railway servants and in some cases settled by the Conciliation Boards. In the case of some companies the claims were referred to arbitration, and the men were generally awarded certain small advances in wages and slightly improved conditions of service. Partly owing to the small benefits which they received under the conciliation scheme, partly because under it the claims of the different companies were treated in different ways by the different arbitrators, partly because the scheme (not unnaturally) took some time to get into working order, and possibly also, it is

* The men were not at liberty to elect representatives who were not in the service of their own railway.

to be feared, because the trade unions never attempted to give it a fair trial, the men were dissatisfied by it, and the dissatisfaction thus engendered was at least the ostensible cause of the strike of August, 1911, during which perhaps as many as 150,000 men were for a short time on strike together. The object of the strikers on this occasion was apparently to force the railway companies to negotiate directly with the officials of the various trade unions, to which a considerable proportion of railway servants belong.

Now, one of the greatest difficulties in devising efficient machinery for the settlement of disputes between the railway servants and the companies is that of ensuring that this machinery shall be used only for the purpose for which it has been called into being, and particularly is this the case where trade unions are concerned. Though a considerable proportion of railway servants belong to trade unions, the larger number do not belong. The trade union officials are always wanting the railway companies officially to recognise their existence, and to negotiate directly with them, on matters which concern the union's own members. If the companies were to agree to do this, it is probable that they would thereby enormously increase the strength of the unions, because those railway servants, who now hold aloof from the unions, would be likely to join in large numbers if the unions once became the recognised channel of communication with the companies. Rightly or wrongly, the companies (except the North Eastern) are reluctant to raise up bodies so powerful as the unions would become, if the great majority of railway servants belonged to them. If it were reasonably certain that the policy of the unions would be directed by the unconstrained good sense of the majority of their members, and if there were any real assurance that the members would agree to be bound by any and every settlement reached by the leaders, there would be great reason for encouraging powerful trade unions to come into existence. But, unfortunately, it is notoriously the case that neither of these conditions can be relied on to obtain in practice. Trade union leaders often have strong political leanings, and make use of their positions to further their own political ideas, and it has lately become quite common for trade unionists to repudiate settlements made on their behalf by the officials of their unions.

A point on which the railway companies lay much stress is that, as they are answerable for the safety of the travelling public, they must be absolutely unfettered as regards the men whom they choose to promote to occupy the most responsible positions, and in the maintenance of discipline; and they fear that if the unions were recognised the officials of the unions would attempt to interfere in questions of promotion and of discipline. The same is the case in matters of policy. For instance, one of the complaints of the men is that, owing to the policy of using bigger engines, which haul trains much heavier than was formerly the case, the number of engine-men required is proportionately reduced, and promotion in this department is retarded. This is, of course, the old story of that increasing efficiency of machinery, which, here as everywhere else, bears very hardly upon the labour which it displaces, but is, at the same time, essential to the increased prosperity of the community, by the very fact that the labour which it displaces becomes available for other productive purposes ; the process of adapting this labour to these purposes is unfortunately a slow and painful one, and it is in no way surprising that the unoffending victims of the process should give vent to the bitterest complaints. Probably, indeed, something ought in fairness to be done to compensate them for losses from which the community benefits. But to give the trade unions facilities for opposing a policy which is to the public advantage is, to say the least of it, undesirable.

The report of the Royal Commission, appointed after the strike of August, 1911, to inquire into the working of the conciliation scheme of 1907, accepted the views of the railway companies as to the undesirability of such recognition being granted to the trade unions as would enable the unions to interfere in questions of discipline and policy. The fact that the report was signed by all the members of the Commission, including those whose sympathies would under no possible circumstances be adverse to any reasonable demands made by the trade unions, justifies in the completest manner the attitude taken up by the railway companies on these points. But, when this is said, there is no reason whatever for assuming that railway servants may not, like other people, have real grievances, and, as it is fairly plain that no Government will ever be able to allow a general railway strike to go on to the bitter end, on account of the suffering and annoyance which would thereby be inflicted on the public, there was urgent need for giving the railway servants suitable means of calling attention to any grievances to which they might consider themselves subject. With this in view, the Commissioners suggested certain simplifications in the conciliation scheme of 1907, which in effect amounted to the abolition of the Central Conciliation Boards; and the proposals of the Commission, with few modifications tending to give the men greater facilities for presenting their case, were accepted by both sides. The question of the recognition by the companies of the men's unions, which threatened to bring about a fresh strike, was settled by allowing the men's secretary on the Conciliation Board to be a person not in railway employ, so that a trade union official may hold this position. Questions of discipline and policy are, however, excluded from the scope of the Conciliation Board's activities.

It is probable that a cause which contributes much to such discontent as exists is want of sympathy with their subordinates on the part of some of the railway officials. As industrial and commercial concerns get bigger and more complicated, the gulf which divides the official and his subordinates widens, perhaps inevitably, and innumerable causes of friction arise through want of sympathy and understanding on the one side, and ignorance and inability to state a case on the other. To these are added suspicions of nepotism and undue influence, in a large proportion of cases possibly groundless, but none the less irritating because they are not disproved. This state of affairs can hardly be considered to be the fault of any one in particular, but is rather one of the unfortunate results of modern industrial conditions, for which it is to be hoped that time will bring a cure.

As many of the railway servants no doubt see, any permanent amelioration of their lot must come from an improvement in the position of the railways, and from every point of view it is very much to be hoped that, by the adoption of improved methods and of labour-saving appliances, the work of each man may be made so much more efficient that it will be possible, and indeed necessary, to raise his wages in proportion.

This of course is the way in which things have been tending of late, and the greatly improved financial results which have been achieved on many British railways of themselves gave reason to hope that means might shortly be available for gradually improving the conditions of the railway servants, though in view of the lean years which the railways have passed through, the shareholders' claims to increased consideration are also strong.

But, beyond the improvements in net earnings due to normal causes, the railways have another source from which they are drawing for the purpose of paying increased wages to their servants. When the strike of August, 1911, came to an end, and the railways agreed to the appointment of a Royal Commission to review the Conciliation Agreement of 1907, they received from the Government an assurance that, if—in consequence of the Commission's recommendations—they should raise the wages of their servants, they should be allowed certain opportunities, over and above what they previously enjoyed, of increasing their charges to the public for the carriage of goods, so as to indemnify them for their increased expenditure. Since the strike the companies generally have made considerable additions to their wages bills, and they have made certain small increases in the passenger fares, which they were free to do without fresh powers; and they are turning to account the fresh powers conferred upon them by the recent Act of Parliament, which was passed to redeem the promise made by the Government in 1911, to increase most of their goods rates—the increased charges generally ranging up to about 4 per cent.

The position of railways as regards their inability to vary their charges in harmony with the general level of prices has not been in the past, and is not even now, a very easy one. Ordinary third class fares practically cannot be raised above a penny a mile, and, under the law until now in force, such ample justification for any increase in goods rates has been required as to make it very difficult to increase them at all. So, while other traders have been free nicely to regulate their charges according to the fluctuations of the market, the railways have been without this power, and, when for any reason the general level of prices has risen, they have had no means of exacting from their customers the increased payments, which would probably have provided the easiest means of satisfying the demands of their shareholders and of their servants. The new Act, no doubt, relieves the situation to some extent, but is very far from making it possible to vary railway charges often enough or widely enough to correspond with the variations in the prices of commodities.

Regarded in the broadest way the truth appears to be that the railways are in several ways much harder pressed financially than they used to be. The increasing efficiency of their methods and of the new machinery which they employ, and the increasing volume of their traffic, have so far only partly set off the general rise in prices which has lately taken place, the very largely increased exactions of local authorities, and the expense involved in the provision of the new machinery and of more elaborate rolling stock. The railways, therefore, have been obliged to hand on part of their new burdens to their men, who, in some cases—perhaps in many cases—are called upon to do more work than they used to do without the purchasing power of their wages being raised to correspond. Indeed, the purchasing power of railway men's wages seems generally to have declined in comparison with what it was fifteen or twenty years ago, as has also the purchasing power of the shareholders' dividends. So, owing to economic causes, both the railway companies and the railway servants find themselves obliged to give as much or more in return for smaller rewards than used to be the case. And, meanwhile, we are assured that the wealth of the community has increased, so that the positions both of railway servants and railway shareholders have in recent years suffered a severe decline in comparison with the general level of prosperity. This state of affairs having at last been recognised to exist, steps are, as we have seen, gradually being taken, partially at least, to rectify it. It should, however, not be forgotten that the object of a railway must always be to secure the highest possible net receipts, and that a reduction of charges, rather than an increase, may be the most satisfactory means of achieving this result.

Secure in the position of its own district, the North Eastern has never been inclined to enter into any closer understandings with its neighbours than the actual working of the through traffic necessitated, and now, when alliances between big railway companies are the order of the day, the North Eastern alone holds aloof, and, going its own way, appears to get on very well. In one particular, however, it has been unfortunate. Whether owing to the North country character, or for some other reason, the North Eastern has been somewhat liable to strikes on the part of its servants, and—apart from the great strike of 1911—once or twice a cessation of work has taken place so sudden and so complete that Newcastle has become on the instant like a beleaguered city.

It would be difficult to decide whether York or Carlisle is the more important junction. It is certainly into these two stations that a greater number of different railways run trains than into any others in the kingdom. But there is this difference, that, while independent railways run into Carlisle from every direction, no railway, other than the North Eastern, reaches York except from a southerly direction, and, even then, over North Eastern metals. To such an extent, indeed, has the North Eastern secured the monopoly of its own district that the whole of the traffic passing between England and Scotland, which does not make use of the North Eastern line, is confined to a belt of country along the West Coast, which gets narrower and narrower till the neck of the bottle is reached at Carlisle.

If at the present time the Great Northern Railway no longer possesses that pre-eminence among other railways, which it used to have in the speeds at which it runs its express trains, this is not because of any relative inferiority in its locomotives. As in old days, the Great Northern singles were some of the finest engines in the country, so now the newer generation of express engines is almost, if not quite, the most powerful class that has yet been constructed in Great Britain.

Single engines have always appealed to the imagination. Their appearance is often very striking, with their great driving wheels which give an impression of immense capacity for speed. For a long time practically all express engines were singles, and, even after coupled engines had been introduced, the singles were often more powerful than the coupled engines, and worked the principal trains, so that, till comparatively recent times, most of the more famous British engines were of the single type. At a time when few express trains weighed so much as 150 tons and troubles from want of adhesion did not arise, the single engine was naturally used, as she fulfilled all requirements, was simple to design and keep in repair, and ran freely. Whether in point of fact single engines as a whole are capable of faster or better work than coupled engines can hardly be decided for want of really comparative trials. Big driving wheels and the absence of coupling rods undoubtedly tend to smoothness of running, and a single is obviously rather cheaper to build and to keep in repair than a coupled engine; but these advantages are by no means overwhelming, and the extremely high place which the singles won in popular esteem seems to have been due as much to the absence of real competition and to sentiment as to the actual work which they did. In particular, the ability to reach exceptionally high speeds, which the big driving wheels suggest, appears to be more a matter of the design of the steam passages than of the size of the driving wheels, and there is no reason to suppose that singles are capable of higher speeds than equally well designed coupled engines. In one very important particular, indeed, single engines (with two cylinders) are less well suited to attain high speeds than coupled engines. In single engines the whole of that portion of the balance weights, used to counteract the backwards and forwards movements of the pistons and piston-rods, which in turn produce a hammering action upon the rails, must necessarily be put in the driving wheels, but in coupled engines it can be distributed among all the coupled wheels, when its undesirable effects are correspondingly reduced. Still the work of many of the singles was of no mean order. No single engines were more justly renowned than the Great Northern engines with 8-ft. wheels, which not only looked as if they could go like the wind, but in point of fact did for many years work the fastest express trains in the world. With their outside cylinders, and domeless boiler—so low-pitched that the top did not emerge very high above the covers of the driving wheels—these engines always attracted attention, and in many ways they presented the greatest contrast to the four-coupled inside cylinder engine, which, while they were still hauling the best Great Northern trains, had already become the standard British express engine, and is so still.

Up to 1898 there were in Great Britain no express engines with more than 8 wheels. The power of 8-wheel engines is fairly strictly limited because, in order to leave a large margin of strength in the permanent way, it is not usual to place more than about 19 tons on any pair of wheels, and this in turn makes it impossible to use a very big and heavy boiler. When, therefore, it was desired to increase the size of the boiler, it became necessary to design engines with a pair of wheels more than had previously been employed. The Great Northern was the first line in Great Britain to build express engines with 10 wheels. The design comprised the usual leading bogie and four coupled driving wheels, with an additional pair of small uncoupled wheels at the trailing end of the engine. The first engines of this type, although considerably more powerful and heavier than any 8-wheel engines which existed at that time, were not made nearly so heavy as the increased carrying capacity of their 10 wheels made possible, and after a few years' interval they were followed by a design which, with the same wheels, was given a much bigger and more powerful boiler. These engines are the standard 4–4–2 * Great Northern express engines of the present day. With the combined boldness and originality of their design, they still have the advantage of being, for their power, rather light machines. This result is brought about by setting the wheels as close together as possible, and securing the power required by means of a short fire-box of much greater width than usual, and a boiler barrel of unusually large diameter. The wide fire-box, a device much used in America, had, up to the time when these engines were designed, hardly been seen in

* Up to quite recently there was no generally recognised way of describing shortly and clearly the wheel arrangements of engines. An ingenious and simple plan, suggested I believe in America, now supplies the deficiency. According to this plan, every engine is regarded as having leading, driving, and trailing wheels, and is described by simply writing down the numbers of wheels in each group, one after the other, a 0 being written in case the engine under consideration does not possess uncoupled leading or trailing wheels. Thus an 8-wheel, four-coupled engine with a leading bogie is written 4–4–0, and a 6-wheel, six-coupled engine, 0–6–0; the big Great Northern express engines are of the 4–4–2 type, and so on.

4-4-2 EXPRESS ENGINE, GREAT NORTHERN RAILWAY.

these islands, and even now there are, outside the Great Northern Railway—and the Brighton Railway, which possesses a few engines of practically the same type—not half a dozen engines in Great Britain which have this feature. With ample means of generating steam, the Great Northern engines have cylinders of only moderate size for utilising it, and are thus machines of that very comfortable type for the driver and fireman, which can always easily produce as much steam as is wanted. The cylinders would, no doubt, theoretically be better inside the frames than outside them, as they are, but the arrangement of the wheels makes the employment of inside cylinders very difficult, and, after all, the smaller degree of steadiness in an engine with outside than in one with inside cylinders does not amount to much in practice.

The 4–4–2 design, since its introduction by the Great Northern, has been adopted by a great many railways for their biggest express engines, and this has been the case especially with the North Eastern and North British railways, the Great Northern's partners in the East Coast route. All three of these lines now possess exceptionally powerful 4–4–2 engines, and the only really conspicuous difference between these engines is in the construction of the fire-box—the Great Northern engines have (as already remarked) the short wide sort, most of the North Eastern engines have the ordinary kind, and the North British engines have the Belpaire. A less noticeable, but none the less important, difference is that the North Eastern and North British engines, particularly the latter, have bigger cylinders and higher steam-pressure than have the Great Northern engines. If engines could be sharply divided into classes intended to work on the level, and classes intended to work up and down steep hills, the former would receive cylinders smaller, in proportion to the diameter of the driving wheels and the pressure of the steam, than the latter would receive, because, while in each class the weight of the steam produced each minute and the most economical point of cut-off were approximately the same, the latter, so long as they were going uphill,* would run slower than the former would run on the level, and their boilers would therefore be capable of supplying more steam for each stroke of the piston. Owing to the extremely varying nature of the gradients of most British lines, it is seldom possible to design engines solely with a view to their performing the most economical work on the level, but the Great Northern main line happens to be exceptionally free from really steep gradients, and the Great Northern designers have turned this fact to account.

In its latest batch of 4–4–2 engines the North Eastern has adopted an almost new arrangement, by employing three high-pressure cylinders, all driving on to the first coupled axle—two outside and the other on the centre line of the engine. In engines of such great power there are, no doubt, advantages in using more than two cylinders, and although, from a mechanical point of view, four cylinders are preferable to three, the three-cylinder arrangement is probably cheaper and offers, in its turn, important advantages over the two-cylinder arrangement in the way of better balancing and greater security from breakdown.

A few years ago many of the engines employed in Great Britain were much smaller than those now in

* Downhill practically any boiler would be considered sufficient.

use, and on many lines it was quite common to see two hauling one train. Even at that time it frequently happened that the train could have been taken by one engine, and—though in a certain number of cases the assisting engine was going home, and was put on to the train merely as means of getting her to her shed—there is no doubt that the practice of piloting had on some railways reached excessive proportions. One of the reasons for this, no doubt, was the view, which some authorities hold, that it is uneconomical to force a boiler. An engine working near the limit of her power is considered to wear her boiler out so rapidly that it is cheaper in the end to employ an assisting engine with driver and fireman complete. That there is very much force in this contention appears highly doubtful, when the clear loss incurred in employing an extra engine is set against the extremely problematical losses entailed by not doing so. In any case, the question of when, if at all, it is advisable to use a pilot engine is obviously to a very large extent a matter of opinion; it is, moreover, clear that a railway, which does not resort to piloting, but expects the drivers to get the last pound of work out of their engines, is more likely to have a staff of efficient engine-men, who will thoroughly understand and look after their engines, than a line which allows a second engine with any difficult train. In the last six or seven years, however, so many much more powerful engines than were formerly employed have been built that the question of piloting has rather receded into the background. Instead of that a fresh difficulty arises, which is to provide the more powerful engines, which now exist, with trains suited to their power. Indeed, on some railways, such, for instance, as the North British, there can hardly be a single train which provides a really adequate load for the bigger engines now in use. And this means that a considerable amount of capital is wasted owing to the engines being much bigger and therefore more expensive than is necessary. It is of course a matter of great difficulty to arrange that the engines shall be neither much to big nor much too small for their work, considering the variety of work which an engine is currently called upon to perform. The tendency now all over the world is to build engines so big that they can always perform without assistance anything they are called upon to do, but when this tendency is carried so far that the engine practically never gets a load which causes her to approach within measurable distance of working hard, it seems as though a sense of proportion were somewhat lacking.

It is not very easy to decide what is the best measure of the power of an engine. The question is much complicated by the enormous difference in the quality of fuel burnt in different engines in different parts of the world, which may make it necessary for one engine to burn twice or three times as much fuel as another in order to produce the same result, and, under such circumstances, without knowing the calorific values of the different fuels used, it is hopeless to attempt to lay down any rule. But even when the fuel burnt is of fairly equal quality, it is not easy to decide upon the most accurate measure. If fire-boxes of approximately the same depth and shape were always employed the area of the grate would probably be the best measure, but the dimensions of fire-boxes vary considerably, and some will hold, in proportion to the area of the grate, so much more fuel than others that some measure, other than the grate area, must be sought. On the whole, perhaps, the area of the opening left free for the passage of the hot gases through the tubes is the most accurate measure. This means that the power of different engines, which burn fuel of the same quality, may be taken to vary as the square of the diameter of the barrels of their boilers.

The principal reason for the increased power of modern engines is the increased weight per passenger of modern carriages. The art of building carriages has proceeded quite as fast as has the art of building engines to haul them, and while British designers have not refused to learn from the designers of other countries, they have also done a great deal of original thinking with satisfactory results. Various lines have at different times introduced Pullman cars, which once were considered to afford the acme of luxury in railway travelling. The Brighton Railway is the only railway which has consistently run large numbers of these vehicles, and whose latest and most luxurious trains are composed of the latest specimens of them. But, though the Pullmans have never taken deep root in this country, the influence which they have exerted upon the design of railway carriages has been out of all proportion to their numbers, and, if at the present time British passenger vehicles are at least equal to any in the world, this is largely due to the fact that the Pullmans showed the British designers that their designs were susceptible of great improvements, and suggested lines of advance, which have since been thought out and acted upon with so much success. Striking indeed is the difference between the shanties on four wheels, which not so very long ago were the standard British railway carriages, and the strongly-built, roomy, and smooth-running vehicles, of which all British main-line trains, and not a few of the suburban trains too, are now composed. In this conservative country the carriages were at first built closely to resemble the stage coaches which they replaced, and only step by step did the stage coach idea disappear, till at the present time the tendency is to make the different kinds of passenger vehicles as much as possible like the rooms of an ordinary house. Owing to the nature and extent of the American territory, the desirability of this course became apparent in the United States long before it did in Europe, but, once the European designers had thrown over their original prejudices, it was discovered that European, and even British insular, conditions afforded ample room for the development of what may be called the dwelling-house theory in the construction of railway vehicles. British designers have not by any means slavishly followed in the steps of their American confrères, and whatever may be the advantages of the American types of vehicle, which commend them to Americans, there is no doubt that British carriages are far better adapted to the views of British travellers than carriages of the American design would be. This is particularly the case in the matter of privacy. In America the carriages, including the sleeping carriages, are, as a rule, without partitions. In Great Britain almost all the carriages except the dining-cars are divided into small compartments. Americans appear to like to be together as much as possible, but an Englishman, after a very short experience of the misery which one baby endowed with lusty lungs can inflict upon perhaps the sixty or seventy occupants of an American carriage, comes to the conclusion that compartment carriages, where a refuge from such inflictions can almost always be found, possess decisive advantages. British corridor carriages with vestibules for passing from one carriage to another, enabling the passengers to move about freely in and out of the dining cars and smoking compartments, render stops entirely unnecessary, except for setting down and taking up passengers, and for locomotive purposes. No development of recent years has been more striking than the increased distances which the principal trains run without stopping. So far as the passengers are concerned, these longer runs are chiefly due to the introduction of corridor carriages and dining cars, while, as regards the engines, their requirements have been met by the installation of water-troughs on nearly all the principal English long-distance lines, and by more perfect lubricating arrangements, which enable the bearings to run for longer periods without attention. Corridor carriages naturally cannot seat so many people as carriages of the closed compartment type,* and, what with the introduction of dining-cars, and the much more solid build of vehicles generally, the weight of the trains has much increased of late years, and there is no doubt at all that passengers, in main-line trains at least, get much more for their money than they used to get. One extremely desirable, though expensive, reform that has been carried out is not perhaps so generally appreciated as it ought to be, and that is the much greater strength of modern carriages, which gives

* Unless the space allowed for each passenger is severely reduced, as is unfortunately done on some British railways.

far increased security in case of accident. Time was when, if an accident took place, it was a constant occurrence for the carriages to telescope, that is, to be crushed together lengthwise, with the most disastrous consequences for their occupants. Present-day carriages are built so strongly that when an accident takes place telescoping does not as a rule occur—though, unfortunately, there are exceptions to this rule—and in some recent accidents it is remarkable how small, for this reason, the loss of life and the injuries have been. So, if these carriages have been expensive to build, there has been some corresponding economy. In another direction, too, the economy must to some extent balance the extra expense. Modern carriages almost invariably run on bogies, which, though they involve some increased expense, by their greater flexibility much increase the smoothness of the motion and diminish the wear and tear of wheels, springs, and rails. The carriages are thereby made easier for the engine to haul, and the expenses of the upkeep of both carriages and permanent way are reduced.

Till the time when corridor and sleeping carriages and dining cars were introduced, the British loading gauge afforded plenty of room, and passenger vehicles were not built up to the full limits of height and width permissible. Since then, however, every available inch of space has been requisitioned. As regards height, the first step taken to provide more light and air was the introduction of clerestories, which a few years ago had a considerable vogue, but the latest practice is to utilise all the space available above, as well as at the sides, and to give the carriages high elliptical roofs.

Perhaps the present-day sleeping carriages, in which each passenger has a compartment to himself, are the most striking examples of the luxury which railways can supply.* Although there is no reason to doubt that a sleeping carriage, even of the most luxurious type, brings in an adequate profit to the railway when it is reasonably full, it is certainly in these vehicles that the ordinary railway traveller gets the greatest amount of accommodation for his money. When it is remembered that the space occupied by each compartment is certainly more than double that which would be occupied by a first-class passenger in a day train, the extra fare charged of ten shillings for a 400 or 500 mile journey certainly does not seem excessive. And it is only since sleeping carriages became so luxurious that the extra fare has been ten shillings ; not so long ago it was but five shillings for any journey. How great a contrast these charges are to those which have to be paid upon the Continent is taught by a very short experience of those of the International Sleeping Car Company. But British railways have never tried to make money directly out of the sleeping carriage supplements, being, perhaps, of opinion that the principal function of these vehicles was to attract to the first-class people who, if there were no sleeping carriages, would have travelled third class, and to induce people to travel who only had time to do so by night, and who, unless they could travel in a really comfortable manner, would prefer not to travel at all.

An East Coast sleeping compartment, containing one person only, fitted with a three-speed electric fan

* Even with carriages built as wide as the loading gauge will allow, a very tall man has in some cases barely enough room to lie full length ; but few people are tall enough to be inconvenienced.

and a lamp, which will give either a bright light or a dull glow, certainly offers very reasonable possibilities of passing a comfortable night. Comfortable as it is, however, and perhaps approaching the limit of what is commercially possible on a large scale, the accommodation which it supplies is far surpassed by that offered in carriages of special construction, particularly in countries where very long journeys are made. In America I once passed the night in a private railway carriage in which I was given to myself a room about 12 ft. by 10 ft., with a balcony outside. But for the ordinary mortal, on ordinary occasions, anything of this sort is, of course, out of the question.

A good deal is heard from time to time about the desirability of providing sleeping accommodation for third-class passengers. So far the railway companies have utterly refused to move in the matter, and have given a conspicuous example of how the absence of any real competition between them enables them to ignore any question which they consider awkward. It is, nevertheless, rather surprising that they should adopt this attitude in a case of the kind. They are offered in this matter an opportunity of securing a reputation for liberality and progressiveness at very small cost to themselves. The only lines, on which any real demand for third class sleeping accommodation exists, are the East and West Coast and Midland routes to Scotland. If third class sleeping carriages were attached to six or seven trains between London and Scotland each way every night, it is probable that any existing demand would be fairly well satisfied. And the expense should be quite small. It is certainly possible to design third class sleeping carriages to contain three beds a side in

EAST COAST SLEEPING CARRIAGE.

the same space as is now allotted to an ordinary third class compartment, which in a corridor carriage holds eight people, so that the extra space required would amount to very little, particularly as sleeping carriages can be better filled than ordinary carriages, because berths have to be ordered beforehand, and the number required is accurately known. The accommodation offered would be by no means luxurious, but the opportunity would be given the third-class traveller of avoiding, by the payment of a supplement, the utter misery which he now endures on a long night journey unless he can secure the whole of one side of a carriage for himself.

Since wood, as a rule, enters largely into the composition of railway carriages, the possibility always exists of their catching fire. So small a thing as a hot axle, or even a spark from the engine, might start a fire, and, when an accident takes place, an escape of the compressed gas carried for lighting or for cooking purposes, or a live coal from the furnace of the engine, may produce the most serious consequences. Indeed, the risk of fire is, perhaps, the chief thing to fear when an accident happens. For these reasons it is important to construct the carriages of uninflammable materials, and it is possible that in a few years' time it will be the ordinary practice to make the sides and roofs and as many of the other parts as possible out of steel; this material, besides being uninflammable, makes very stiff and strong carriage bodies, which offer great resistance to telescoping. In America, where fires are much more common than in Europe, and where the railway carriages are often so difficult to escape from as to be perfect death traps, the use of steel bodies has made more progress than here, but the accident which took place not very long ago near Hawes Junction, and the more recent accident at Ditton Junction, in each of which several people were burnt to cinders, drew attention sharply to the importance of making British railway carriages as little as possible liable to catch fire. At the same time it must not be forgotten that, even if the bodies of passenger vehicles were constructed entirely of steel, it would be practically impossible to exclude all inflammable materials from the inside fittings, and even the clothes and hand-luggage of the passengers might, under certain circumstances, produce smoke, which would asphyxiate persons who were trapped in a carriage. Under such circumstances the fact that the carriages were constructed of steel, which is much more difficult to break through than wood, might quite possibly make the results of an accident worse rather than better. The whole question, indeed, of providing an easy means of escape from railway carriages after an accident has taken place is of great importance. On main line journeys, when stops are infrequent and of some duration, doors at either end of corridor carriages are sufficient for normal requirements, but may be quite insufficient in case of an accident, and must be supplemented by other means of exit. In this country, therefore, corridor carriages are generally given the same number of doors as ordinary compartment carriages. An objection to doors as emergency exits is that when an accident takes place it may easily happen that they become jammed, so that it is impossible to open them. Some dozen years ago the question was carefully gone into by the Prussian State Railways, in consequence of a serious accident which had taken place on one of their lines, and it was decided that the safest plan was to retain the arrangement of doors at the ends only, but to make the windows very large and easy to open, and to provide suitable hand-holds and foot-holds so as to enable the passengers, if necessary, to escape by the windows.

In suburban trains, besides the question of safety, that of filling and emptying the carriages in the shortest time is of importance. If the passengers could be prevailed upon always to enter the carriage at one end and to leave it at the other, and if a central passage could always be kept clear, doors at either end would, no doubt, be a good and sufficient arrangement. As, however, these conditions appear to be unattainable, it is not surprising to find that the ordinary arrangement of side doors is usually retained for suburban trains.

Accidents have been known to occur through a wheel working loose upon its axle. A wheel is secured upon its axle by having its centre bored out to a diameter very slightly less than that of the axle, which is then forced on by hydraulic pressure. This pressure should amount to something like eighty tons. If the axle is a little too small, or the hole in the wheel a little too big, the pressure required to force the axle into the wheel is not great enough, and it may possibly work loose in service. In some carriage shops, therefore, a machine is used which automatically records the pressure exerted, and this makes it almost impossible for an insecurely fastened wheel to be put into service.

Another most important machine in the carriage shops, tending this time to ensure the comfort of the passenger, is one in which the carriage wheels are revolved to ascertain whether they are properly balanced. If they are found to be in any way defective, a metal plate of the required weight to effect the proper balance is fastened on to the inside of the wheel. Quite a small departure from the proper balance has a very bad effect upon the running of a wheel, causing it to tend to swing backwards and forwards in the axle-box guides.

The cleaning of the carriages, which is a serious business, is, in large centres, often done largely by means of a vacuum cleaner. There is a large central installation where the vacuum is maintained, and from here led by pipes wherever a vacuum is required for cleaning purposes. If there are building or repairing shops near by, the same vacuum can often be made use of in them for a variety of other purposes.

The lighting of railway carriages has always been rather a difficult problem. For a long time no serious attempt was made to provide more light than was enough to differentiate light from darkness. Anything like reading by the exiguous rays of the candles originally provided was, of course, out of the question, and the dirty oil lamps, which lasted for so long, were almost equally devoid of any real utility. These were the dark days of railway travelling. Since then, although the difficulty in the way of giving each passenger light enough to read by, and at the same time providing general illumination for a whole compartment has not yet been quite satisfactorily overcome, really serious attempts to solve the lighting problem have been made. For some time now the competition has been between gas and electricity, and, so far, the race has been very even, and it is impossible to say which illuminant will in the end secure the preference.

First gas got the start, then electricity made greater progress, then improved incandescent mantles gave a fresh impetus to gas, while more perfect electrical appliances were being evolved by the electricians. Where electric light is used as few heavy accumulators as possible have to be carried, so, while they are indispensable for providing electricity as long as the train is standing still, the current required is procured from a dynamo as soon as possible after the train starts. The dynamo is driven from one of the carriage axles by means of a belt. Whatever may be the pace of the train, the current required for the lamps is the same, and so a good deal of ingenuity is necessary to arrange for regulating devices, which will ensure that the proper supply shall always reach the lamps, and this without wasting more energy than is absolutely necessary, for all the power has to come from the engine, and, if it is wastefully used, there is unnecessary expense. A drawback of electricity is that, in case of fog, when the trains may have to crawl along for hours together, the accumulators may give out, and there is then no opportunity of re-charging them from the dynamo, so that the light may fail altogether. Gas possesses an advantage over electricity in that a supply is taken in before the train starts, and it has not to be made *en route*. It is generally manufactured by the railway company at a special gasworks, and is stored in cylindrical holders underneath the carriages, which, as it is compressed to a high pressure, can hold a large supply. From the cylindrical holders it is led at a reduced pressure to the burners, where the now generally used inverted incandescent mantles enable a very small amount of gas to give forth an extremely bright light, and one which, unlike electricity, has no need of being nicely regulated to counteract variations in the speed of the train.

Where a number of carriages are always coupled together, the electric lighting arrangements may be simplified by generating and storing the electricity on one carriage only, but any carriage, which is liable to be detached from the others, must have sufficient storage capacity to last at least till it can receive a fresh supply. In connection with carriage lighting the ever-present danger of fire has to be carefully considered; in this respect, electricity, though certainly not entirely safe, possesses advantages over gas, an escape of which, when an accident takes place, is too frequently the cause of a fire. Something can, however, be done to minimise the danger from gas by fixing the gas cylinders as closely as possible under the frames, where they get the greatest amount of protection, and by arranging valves, which automatically cut off the supply of gas when the pipes get broken.

CHAPTER II

THE RAILWAYS OF CENTRAL ENGLAND

Midland Railway—The Engines of the Midland Railway—Railway Geography—Great Central Railway—Lancashire and Yorkshire Railway—Goods Wagons—Goods Station at Leeds—Train Control—Toton—Multifarious activities of Railways—Standardisation—Rates and Fares—Clearing House—Canals.

THE Midland, unlike almost all the other railways which have their termini in London, does not regard the Metropolis as its headquarters. Its London extension was only an afterthought, and, important as its traffic on that and other extensions now is, the principal activities of the Midland are devoted to its interests in the centre of England. Its headquarters are at Derby, which is almost the geographical centre of the system, and it is upon the centre of England that all its chief lines converge. But, if the central part of its territory is its special care, there is no railway in England which has shown so much enterprise in reaching out towards parts of the country remote from its centre. Outside the central area, the Midland has its own lines to London, Manchester, Bristol, Carlisle, and Heysham, and by means of joint railways or running powers can run its trains to Cromer and Yarmouth on the east coast, to Bournemouth on the south coast, to various points on the Bristol Channel, to Liverpool, and to Stranraer in Scotland. A few years ago also the Midland bought the Belfast and Northern Counties Railway, so that it possesses several hundred miles of railway in Ireland.

The Midland has lately expanded in a fresh direction by absorbing the London, Tilbury and Southend Railway. The Tilbury was a prosperous little line, occupying a corner of what the Great Eastern probably always regarded as its own district, making use of that company's terminus at Fenchurch Street, and working generally in harmony with it. It can have been with no very pleasurable feelings that the Great Eastern learned of the contemplated incursion of the Midland into this new district, an incursion which shows that, though the principle of territorial aggression between railway companies has generally been abandoned, there may still be cases in which some company or other finds its practice advantageous, and that the new grouping of the companies cannot be expected to leave each group with the undisputed supremacy of the whole of its own district. The Midland has expanded in so many unexpected directions that it is impossible to be sure what it will do next. There are many things less likely than that it will renew an attempt previously made to absorb the Glasgow and South Western Railway, and thus secure a line of its own the whole way from London to Glasgow. After this, there would still remain the north-east and south-east of England in which to secure a footing. In the north-east the North Eastern Railway's position is probably impregnable, but the eventual absorption by the Midland of the South Eastern or the Brighton, although a far greater undertaking than it has yet carried through, does not seem entirely out of the question. Now that there is a possibility that coal may be worked in Kent on a large scale, there would be a certain fitness in the transport of that commodity's being undertaken by the greatest of all the coal-carrying lines.

Great Britain does not lend itself to a neat scheme of railways. A long, straggling country with the capital near one corner, the most populous centres scattered irregularly about, and a high ridge of hills dividing the two most important manufacturing districts, presents a combination of conditions which would make it difficult to plan a really economical scheme of lines, even if we now had to begin again from the beginning. As it was, no attempt was made to plan the railways as a whole, as was done in France. The population of innumerable towns was so large that it appeared profitable to build purely local lines, many of which could have been improved, or dispensed with altogether, if British railways had from the beginning been planned with a view to the service of the country as a whole. Added to this, there was the rather vague idea that railways should be made to compete with one another, and the consequence is that in many cases two or more lines exist between points which could be served by one. The principal lines of the Midland follow rather nearly the directions which, perhaps, many of the ideal lines would take. If it were possible to rearrange the railways it is pretty clear that London should not be, as it now is, the principal centre. This would have to be removed to some place in the centre of England, through which the greater number of the chief main lines would pass. It should be in some unoccupied spot, where it would be possible to construct one huge junction, which could be approached from all sides. The most suitable spot would appear to be somewhere a little south of Derby; this would be an excellent point of intersection for the two principal lines, which would replace the existing south to north lines. One of these lines would start from London, and, skirting the southern slopes of the Pennine chain, pass close to Manchester, and, from about Preston, continue to Glasgow along the present West Coast route. The other would start at Plymouth, and, passing Exeter, Bristol, Birmingham, Sheffield, and Leeds, join the present East Coast route about Darlington, and continue thence as at present to Edinburgh. A third main line, intersecting the others at the central junction, would run from Holyhead to Yarmouth. Two or three lines across the Pennine chain would connect the manufacturing districts on either side of it, and a line from Cardiff along the right bank of the Severn would join the Plymouth-Edinburgh line about halfway between Bristol and Birmingham. There would be main lines from London to Norwich, Dover, Brighton, and Bournemouth, very much as at present, and one main line from London to the west, taking the same course as the direct Great Western line now takes, but with a branch from somewhere about Devizes to Bath, Bristol, and the Severn Tunnel. Some such scheme would greatly reduce the length of main line required, and at the same time leave the distances between the principal cities much as they now are. But these are vain speculations, and, even if we cannot but think that the national energy might have been better spent than in providing, say, the three different routes which exist between London and Sheffield, it cannot be said that any of them suffer acutely from want of traffic, or are in danger of becoming derelict.

As might be expected, the central district of the Midland is so full of junctions, and contains so many big towns, that, even on the main line, there are a considerable number of obstacles to rapid progress, but away from this district some of the principal lines were built later, and more with a view to express through traffic. The gradients, however, of most of the principal Midland lines are steeper than the average in Great Britain. This is particularly the case with the line from Derby to Manchester, where there is a good deal of 1 in 90, and from Leeds to Carlisle, where there are long stretches of 1 in 100, and the summit of the line is 1167 ft. above the sea. It is, therefore, only on the London main lines, south of Trent or Nottingham, that many trains are timed at more than 50 miles an hour. On these sections a good many of the best trains reach 56 miles an hour, start to stop; although speeds very much higher than this could be achieved without difficulty over almost any of the principal British main lines, there is in point of fact but little locomotive work in the country which with regard to speed over moderately hard gradients is superior to that of the engines which work these trains.

Like so many other companies, the Midland has lately given much attention to superheating in locomotives. It was not among the first to take up this question seriously, possibly owing to the great success achieved with the 3-cylinder compounds; but, now that the Midland authorities have convinced themselves of the value of superheating, they are applying it—to the passenger engines at least—on a large scale. It is now a long time since any really new design of engine has been produced by the Midland. The first compound started work quite ten years ago, and about the same time the Belpaire fire-box was adopted for simple express engines, but since then, except for the adoption of superheaters, any developments that have taken place have been in the nature of modifications in details. With the adoption of the superheater, the Midland has still abstained from bringing out a completely new design of engine, but, having on hand a large number of engines well suited for being rebuilt with superheaters, is now in process of adapting them to one standard with so many changes from the original designs—even the frames are new—as to make of them practically a new class of engine.

The object of all superheaters is first to dry, and then to raise the temperature of, the steam on its way from the boiler to the cylinders. So long as steam is in contact with water, its temperature cannot rise above that of the water, and it is always heavily charged with minute drops. If, after being led away from contact with the water, it is further heated, the drops are all turned into steam, and the dry steam itself quickly increases in volume, and becomes a far more active and rapidly moving fluid, and a much worse conductor of heat, than in its wet condition. There are different kinds of superheaters, some being designed to raise the temperature of the steam much higher than others. They generally consist of small pipes placed inside some of the boiler tubes, which are specially enlarged for the purpose, and through which, when steam is shut off, the draught is checked by means of specially arranged dampers; through these small pipes the steam is led on its way from the boiler to the cylinders. The Schmidt superheater, which is one of those which greatly raise the temperature of the steam—up to 700 degrees Fahrenheit—is the pattern most widely used. This superheater is employed by the Midland, but the superheater tubes are fitted on to the header by means of a new and simplified attachment designed at Derby, and there is an ingenious arrangement, also of Derby origin, for securing the full benefit of the superheater when the engine is working a stopping train. A system of valves, placed on the side of the smoke-box, prevents the superheater from getting cold during stops, and prevents it, at the same time, from getting too hot while there is no steam in it to carry off the heat.

The advantage to be obtained from the use of superheaters is no longer in doubt. (If the efficiency of an ordinary simple engine, without a superheater, or feed-water heating, is taken to be 100, the Midland calculates that a compound has an efficiency of about 107, and a superheater engine an efficiency of about 122.) But there is a good deal of doubt as to the precise behaviour of superheated steam, and why it shows all its unquestioned economy. The principal reason, indeed, for the economy shown is, no doubt, that when steam has once reached the point of being absolutely dry, a comparatively small addition of heat produces a comparatively large increase in volume. But, beyond this, the part played by the greater lightness and fluidity, and the smaller conductivity of heat of superheated, as compared with saturated, steam, is at present little understood. The Midland has given one of the rebuilt engines cylinders of the same diameter as are given to engines working with saturated steam, so as to make possible strictly comparative trials, which, it is hoped, may throw light on the questions which are now obscure.

Though the superheaters and the compounds are now the most powerful express engines on the Midland, they are not yet sufficiently numerous to work all the best trains, with which, therefore, other classes of engines take their turn. On a journey which I recently made with the 1 p.m. luncheon car train from Leeds, the train was hauled throughout by ordinary simple engines without superheaters. These engines—of the 770 class, with Belpaire fire-boxes and driving wheels 6 ft. 9 in. in diameter—are, nevertheless, large and powerful machines, and admirable specimens of what was very nearly the last word in the designing of that type of 4–4–0 engine, into which no special device for economising heat was introduced. On the day on which my journey was made it happened that an exceedingly strong wind from the east was blowing across the line all the way, so that the engines were obliged to work much harder than would otherwise have been necessary. Starting from Leeds, No. 735 had 297 tons, exclusive of passengers and luggage, say 320 tons all told, behind the tender, and, though the line is fairly level, she had to work hard to reach Masboro'—nearly 34 miles—in 45 mins. 50 secs., with a signal stop near the end of the run. From Masboro' the first part of the train goes forward to follow a devious route via Sheffield and Nottingham, and eventually to reach St. Pancras at 5.25 p.m.; and another engine backs on to the remainder of the train to haul it the 162 miles to St. Pancras—via the direct line, which avoids Sheffield and passes through Leicester—in 177 mins., without a stop. The new engine turned out to be No. 729, of the same class as No. 735, and the weight of the train was now reduced to 160 tons, say 170 tons with passengers and luggage. As before remarked, the Midland between Leeds and Trent is not a favourable line for really fast running, and, what with crossing over from one line to another before Chesterfield, the service slack at Clay Cross, an extra slack at Toton, and the service slack at Trent, the 42 miles to passing the last-named place occupied exactly 50 minutes. After Trent we were able to push ahead a little on the nearly level stretch to Leicester, in the course of which we passed over the first water-troughs which we had encountered; here, by a few turns of a lever, the driver let down the tender scoop, and in a few seconds the tender again contained its full load of water. Shortly after this a permanent way slack lost us another ½ minute or so, and, as we had left Masboro' 4 minutes late, we had, as we ran slowly through Leicester station, only 99 minutes left to run the same number of miles. Now, for an engine as big as No. 729 to keep up an average speed of 60 miles an hour for such a distance, over a road no harder than the Midland, with only 170 tons behind the tender, would not, under ordinary circumstances, be a specially difficult task. But to-day the great strength of the side wind, which was probably sufficient to make all the flanges of the wheels on the right-hand side of the train grind hard against the rail, converted what would normally have been an easy matter into something much more difficult. Fortunately, the engine was steaming well, and, in spite of the really terrific force of the wind wherever there was no shelter from a cutting or from the natural lie of the country, the speed kept up so well on the numerous lengths of rising gradient that, without forcing the pace downhill in any way, we should have arrived just about punctually at our destination, if we had not encountered a slack before Kettering, which, on a favourable stretch of downhill, reduced our speed to 30 miles an hour. As it was, we arrived 2 minutes late, but, in spite of the delays which we had suffered, we had still saved 2 minutes on the booked time. The best work was done between Market Harboro' and Desborough, where the 5 miles—nearly all at 1 in 132 up—were run in just $5\frac{1}{2}$ minutes, and up the long rise between Bedford and Leagrave, where the distance of a little over 17 miles, occupied 17 mins. 20 secs. (for the first 16 miles from Bedford the gradient averages 1 in 264 up). On both these ascents the engine must almost certainly have been developing more than 1000 horse-power continuously.

The route which we had taken, avoiding Sheffield on the one side and Nottingham on the other, ranks as the principal main line of the Midland, but the short loop on which Sheffield stands and the much longer one which passes Nottingham, are, both of them, followed by a large number of express trains, and are practically equal to the main line in importance. The fact that different trains follow different routes for a large part of the way between St. Pancras and Leeds gives the main line of the Midland a certain want of definition that is not found in connection with the main lines of other companies. This state of things will shortly be intensified by the completion of a loop running through Bradford and avoiding Leeds. This is one of the latest enterprises of the Midland. The matter has, indeed, been before the company for some time, and various schemes have been proposed, but now, at length, the new works are being put in hand. A new section will be built to complete an alternative route between two points on the existing main line on either side of Leeds, and this new route will probably be the shortest way for Midland trains to reach Carlisle and Scotland.

More closely connected with the Midland than any other Scottish company is with any English one, the Glasgow and South Western Railway forms the continuation of the Midland to Glasgow. The Midland route is 20 odd miles more than the West Coast route, and the times between London and Glasgow are longer, so that the West Coast gets the bulk of the passengers travelling all the way. But the Midland passes so many important places *en route* that there is a large traffic between Glasgow and intermediate points, like Leeds and Sheffield, which the West Coast trains do not touch. To Edinburgh the Midland trains have to travel over the very hard Waverley line of the North British, and here, in the same way, the route from London is longer than either the East or West Coast routes, and the trains take more time. But, as to Glasgow, though to a less extent, the Midland secures the Leeds and Sheffield traffic to Edinburgh and beyond, and it is presumably because of its traffic to places beyond Edinburgh that the Midland is a shareholder in the Forth Bridge, of which it can otherwise make very little use.

Of all the many railways with which the Midland comes into contact, there is none which it touches at a greater number of points than the Great Central. As regards the Great Central itself, hardly any point on the system is more than a few miles away from the lines of some other company. Its traffic, a very large proportion of which is mineral traffic, is almost all to and from populous centres, but it has at the same time very little suburban traffic near London. It is not one of those companies which were from the beginning designed to run to London, but it had its origin in the industrial districts of the Midlands. As time went on it began to cast longing eyes upon the Metropolis, where such a small area promised such immense possibilities of profit. It is now more than forty years since the Midland, which before was dependent first on the North Western and then on the Great Northern for its entrance into London, found itself obliged to make a way for itself over the (from a railway point of view) comparatively desert stretch of country which separates Bedford from the Metropolis. For a considerable time no one thought that another of the northern companies would ever be inclined to face the great cost that an extension to London would involve; but in the early '90's the Manchester, Sheffield, and Lincolnshire Railway, dissatisfied with its position, which made it hardly more than the gathering ground for traffic, particularly coal traffic, from which other companies, to whom this traffic had to be handed over, secured the chief profit, received the authorisation of Parliament to extend its line to London. In 1898 the London extension was complete, and the name of the railway was changed to " Great Central." It had not been necessary to construct a new line the whole way south of the old Manchester, Sheffield, and Lincolnshire's district, as running powers were secured over nearly 40 miles of the Metropolitan Railway immediately outside the London area. Subsequently, however, with the help of the Great Western, a new loop was constructed to the west of the Metropolitan line, which gave the Great Central another route into London. (This loop increases the distance between London and the north by some $4\frac{1}{4}$ miles.) So now the Great Central has become one of the established main routes from the north to London, but not yet has it recovered from the financial strain which its extension imposed upon it. To effect an entry into London, capital had to be poured out like water, and the increase of traffic, which the new line brought, has been very far from sufficient to pay interest on all that capital. The line, however, being built in the light of modern experience, will be able to cope with the intense traffic, which it will one day be called upon to accommodate, without further costly improvements. The rolling stock is of more than average efficiency, the engines in particular being, for the most part, large and powerful. The latest design in particular is probably the most powerful 4–6–0 2-cylinder engine at present running on any line in Great Britain.

In its present form the Great Central has three distinct centres, connected one with another only by the main line. The Manchester district is connected with the Sheffield district by the single pass across and through the Pennine range, and the latter district with the Metropolitan district by the long ribbon of the London extension.

The Great Central is by no means resting on its oars, but is losing no time in consolidating its position and improving its prospects in various ways. Not long ago it completed at Wath a new sorting yard of colossal dimensions, where an immense volume of coal traffic is cheaply and expeditiously dealt with, and a subsidiary company has just constructed at Immingham, on the Humber, a gigantic series of docks, into which will overflow the traffic, which is being crowded out of Grimsby, a few miles away.

The Great Central, having made its way to London, in the face of the strongest opposition, did not take very long to make up its mind that, once there, the best thing to do was to make close friends with some of its neighbours. The Great Northern and the Great Eastern systems, if joined to that of the Great Central, would cover the east of England between the Humber and the Thames almost as completely as the North Eastern covers the north-eastern corner of England. An alliance, therefore, of the most complete kind was projected between these three companies. The net receipts were to be divided in agreed proportions, and the lines worked as one system. The alliance, indeed, was evidently intended to amount to an amalgamation of the three lines, quite as complete as the amalgamation of the South Eastern and London, Chatham and Dover. The opposition, which the project encountered in and out of Parliament, caused the withdrawal of the bill which was promoted to secure Parliamentary sanction for the amalgamation, but it seems quite probable that the project will be revived at some more convenient season. Meanwhile, the harmonious co-operation of the three railways on a

4–6–0 EXPRESS ENGINE, GREAT CENTRAL RAILWAY.

less extended scale secures for them some, at least, of the economies which amalgamation was intended to effect.

The Lancashire and Yorkshire is a line which lends itself to comparison with the Great Central. Very close neighbours, both extend from east to west across England, and each has an important eastern and an important western district, which are joined together by a single pass through the Pennine Hills. The Lancashire and Yorkshire, however, is much the more compact system, and less exposed to possible competition, and the density of its traffic is far greater. With a much shorter mileage, the Lancashire and Yorkshire has, even now, a considerably greater paid-up capital than the Great Central, and earns more than proportionally large profits. Indeed, the Lancashire and Yorkshire, with its network of lines closely embracing its numerous Yorkshire, and yet more numerous Lancashire, centres, is in a thoroughly comfortable position, and has not felt impelled to any such ambitious scheme as urged its southern neighbour to London.

Besides working its own trains, the Great Central provides engines to work the trains of the Cheshire Lines Committee in those parts of Lancashire and Cheshire where the Midland, Great Northern, and Great Central have pooled their interests in the common undertaking, known as the Cheshire Lines. All the three companies have large interests in both Liverpool and Manchester, and have to be able to run direct between the two cities, so, instead of each possessing its own line, or having running powers over another line, the three companies have united to finance and work this undertaking, which, besides the main line between Liverpool and Manchester, comprises some hundred miles of railway in the adjoining district. Such of the trains which run over these lines, therefore, as do not belong to one or other of the owning companies, are the property of the Committee which consists of nine members—three of the directors of each of the three companies—and the working is mostly entrusted to Great Central engines.

Of the three routes—North Western, Cheshire Lines, and Lancashire and Yorkshire—between Liverpool and Manchester, that of the Lancashire and Yorkshire is appreciably the longest, so for the company to run its trains, as it does, in the same time as its competitors, necessitates work which is of more than average merit. All the best trains cover the distance of nearly 37 miles, which separates Liverpool from Manchester, in 40 minutes, and, as there are plenty of steep uphill bits, quite long enough seriously to reduce the speed, this involves fairly good work on the part of the locomotives. But there is no railway company that has engines capable of giving a better account of themselves than the Lancashire and Yorkshire. The company is fortunate in having had the services of a series of chief mechanical engineers of great enterprise and originality, and new ideas have always received a warm welcome at the locomotive works at Horwich. Twelve or fourteen years ago, when the desirability became apparent of building engines of much greater size than had up to that time been usual, the Lancashire and Yorkshire was one of the first to adopt the 4–4–2 type, and at the present time the company's newest express engines with 4 cylinders and 6 coupled wheels are almost the most powerful type at work in England. Among numerous experiments tending to the improvement of locomotives, the Lancashire and Yorkshire engineers have devoted considerable attention to the question of fire-boxes. They were among the first definitely to adopt the Belpaire fire-box, and they have made trials of a cylindrical fire-box, which, if it could be generally adopted, would offer great advantages in the way of cheapness and durability.

The fire-box, the most important part of the boiler, is, from the nature of the case, the part which is exposed to the greatest wear and tear, and which is obliged to submit to the greatest strains. The great and sudden changes of temperature, to which fire-boxes are subject, cause equally great and sudden expansion and contraction, and, as the fire-box and the ends of the tubes nearest the fire-box are the only parts of the boiler which are exposed to these rapid changes of temperature, there is no corresponding expansion and contraction of the rest of the boiler to mitigate their effects. The fire-box itself is, in England, always made of copper, because copper is much softer and less rigid than steel. These qualities are, if anything, more necessary in the tube-plate then elsewhere, as the tube-plate is subject to the thrust of all the highly heated tubes, and if it does not yield to this thrust the tubes are bound to leak—one of the most common and most tiresome defects in a locomotive. Very rigid are the curved outer shells, which contain fire-boxes of the ordinary type, and for a long time it has been recognised that something should be done to provide greater elasticity. One of the principal advantages of the Belpaire fire-box is the fact that the top of the outer shell is flat, and, therefore, more yielding than the older curved design. But with the increase in the size of engines, and in the pressure of the steam, more radical remedies are required for overcoming the defects of fire-boxes. In France the Chemin de fer du Nord sought a remedy in the use of a fire-box with walls composed of series of water tubes. This fire-box was much stronger in form and much freer to expand and contract than an ordinary fire-box. The water circulated from the barrel of the boiler to a drum on either side of the bottom of the fire-box, and rose thence through the water tubes of small diameter to another drum, whence the steam, generated on the passage of the water through the tubes, entered the barrel of the boiler. But this experiment has now been abandoned on account of the complication of the arrangement. In America an arrangement is being tried, whereby the ordinary system of stays screwed through both fire-box and fire-box shell is superseded by a system of parallel steel plates, forming sort of ribs, and to these, inside and out, are rivetted steel channels, which form both the fire-box and the fire-box shell.

The careful thought which the Lancashire and Yorkshire devotes to its steam locomotives has not in any way diverted the company's attention from the question of electric traction. The Lancashire and Yorkshire was the first company to electrify a length of standard railway, which had before been worked by steam locomotives. The Liverpool to Southport line has now been worked by electricity for a considerable number of years; a very frequent service is carried on along it with regularity and efficiency, and the company's engineers have secured first-hand experience of electric working, which will be most valuable now that the question of further electrification of the railways in the populous part of Lancashire has come so much to the fore.

In the south of England the railways depend for their profits chiefly upon the passenger traffic—nearly three-quarters of the incomes of the South Eastern and Brighton Railways come from passengers, and much more than half that of the South Western. Near the other end of the scale come the lines, which serve the coalfields and industrial districts of the Midlands and north of England, for which the relative importance of the goods and passenger traffic is reversed. The Midland gets less than a third of its receipts from passengers, and the same is the case with the Great Central.

In working the goods traffic a compromise is necessary between the interests of the railways and of their customers. The railways like full train loads of fully loaded vehicles, their customers like their consignments to be delivered with as little delay as possible. These two aims are often incompatible with one another. It may take a long time to collect enough goods to load a vehicle fully, and a still longer time before there are enough fully loaded vehicles to make up a train for any given destination.

The 4-wheel wagons, which are almost exclusively used for goods traffic in this country, cannot carry a very large weight of goods in comparison either with their own dead weight or with the space which they occupy in the sidings and goods stations. It is possible to construct vehicles much more economical in both these respects. But in Great Britain the consignees insist upon so much of the goods traffic being delivered without delay that it is found more convenient to transport all sorts of general merchandise in vehicles of small capacity. No doubt there are many cases where full loads could be secured regularly for vehicles of much larger size than those in actual use, but, although employment might be found for a certain number of such vehicles, so many cases would still arise, where the small 4-wheel wagons were big enough, that these would have to be used in conjunction with the bigger wagons, while, at the same time, so much expense would be incurred in adapting the goods stations for the reception of the big wagons that it is quite doubtful whether any economy would result from their use. For general merchandise, indeed, it very often happens that the 4-wheel wagons, far from being too small, are much too big, and one loaded up to its full capacity is, in some places, rather a rare object. But, though the 4-wheel wagon is nearly always amply big enough for general goods traffic, the case is different where heavy mineral traffic is concerned. Here there is some scope for the introduction of the big wagon, with its attendant advantages of greater paying weight per train, and greater economy of space at the loading and unloading stations. Up to about the end of last century the small 4-wheel wagon reigned supreme for mineral as well as general goods traffic, but the comparatively evil days, on which the railways then fell, directed attention to the economies which might be effected in the working of the goods and mineral traffic. It was then that stricter attention began to be paid to the loading of the goods trains, with the result that hundreds of thousands of miles of goods mileage per annum were saved, and the possibility of using larger and more economical vehicles for suitable classes of traffic was seriously taken into consideration. Since then this latter reform, though it has not been lost sight of, has, it must be confessed, proceeded rather slowly. But still some progress has been made, and a number of 8-wheel vehicles of large capacity are now in use on the Midland, North Eastern, and other railways.

All sorts of unexpected difficulties constantly crop up when a new departure of this sort is tried. At Derby I was shown a steel wagon, used for carrying coal, and built only ten or twelve years ago, the floor of which had wasted away to the thickness of half a crown, so that it was no longer safe and was about to receive a wooden floor covering. It appears that when it rains the rain water, percolating down through the coal, absorbs some of the sulphur, which the coal contains, and so becomes like very dilute sulphuric acid and attacks the steel floors of the wagons with serious results.

The question of the employment of bigger wagons is a large one, as there are several hundred thousand mineral wagons in Great Britain, and, if it were only a matter of gradually replacing such of these as are engaged on traffic for which the wagons of large capacity would be more economical, it must take some years to solve, particularly as most of the mineral wagons do not belong to the railways at all, but to private owners, who might be very hard to convince of the desirability of the change. But, besides the actual replacing of one kind of wagon by another, at all the places throughout the country where the wagons are loaded, unloaded, or manœuvred, modifications must also be introduced for the accommodation of the bigger vehicles, and these modifications would not be the easier to carry through from the fact that, like the wagons, many of the places where these modifications would be necessary do not belong to the railways, but to private owners.

There are so many objections to the use of private owners' wagons, and so few advantages, that it is difficult to understand how the British system of allowing private owners to use their own vehicles has been permitted to go on. A private owner's wagon can obviously not be utilised to the same extent as a wagon belonging to a railway company, which can be sent anywhere, where there may happen to be a demand for it, the moment it is empty, and although the railways no doubt take great care to ensure that the wagons, which they accept to run over their lines, are of proper design and suitable strength, they can hardly exercise the same degree of supervision over them as over vehicles belonging to themselves. Then, questions connected with the rights of private owners to run their own vehicles over a railway may, and sometimes do, cause litigation, and other questions, such as allegations of undue preference shown in moving vehicles belonging to the railway before vehicles belonging to private owners, can hardly fail to arise from time to time. Private persons in the greater part of the North Eastern Railway's district do not own any wagons, and one or two other companies, such as the Midland, have made large purchases from private owners. But there does not seem to be much probability of the purchase of private owners' wagons going further for the present.

The working of railways can never be a perfectly safe pursuit, and one of the most obvious dangers is that of being either run over or crushed by moving vehicles, a danger to which those men who are engaged in shunting and marshalling operations are naturally the most exposed. The carelessness bred of familiarity is sure always to claim a certain number of victims, whatever safeguards are employed, but when it is unnecessary for the men to go in between the vehicles, the risks which they run are very greatly diminished, and the death-roll due to shunting accidents has caused special attention to be directed to this point. The desired result may be effected in various ways. In Great Britain the use of shunting poles enables the shunters to couple the wagons while they are themselves standing in positions of safety, where no moving vehicle can strike them. It is possible to go further than this, and, by means of automatic couplers, to arrange that two vehicles, when brought together, shall couple of themselves without the intervention of any outside agency. This system, universally used in the United States for vehicles of every kind, is not employed to any appreciable extent in Great Britain. Automatic couplers, of which there are numerous kinds, consist essentially of a large, strong hook, movable round a pivot, which, engaging with a corresponding hook on another vehicle, is then locked in position by a special mechanism, which the shock of coupling puts into action. One objection to the use of automatic couplers lies in the difficulty of designing a coupler which will stand the tremendous shocks to which it is frequently subjected in coupling operations. An automatic coupler is necessarily a somewhat complicated piece of mechanism anyhow, and, to be really effective, there must also be an arrangement to enable the shunters to unloose it, without going between the vehicles, which makes it more complicated still. In point of fact automatic couplers are very liable to get out of order, and require constant attention to keep them in a proper state of repair.

Besides the coupling and uncoupling, which goes on during shunting operations, the brakes have frequently to be put on or released, and, unless the shunters are continually to be running into danger by crossing the rails, it must be possible to apply or release the brake from either side of a wagon. Obviously it is a difficult matter to provide mechanism which will permit of the brake's being applied from either side, and then, if necessary, released from the side opposite to that from which it has been applied. The Board of Trade, having for many years, at more or less long intervals, urged upon the companies the desirability of using all their endeavours to evolve or discover such a brake, has now decided to be satisfied if brake levers are fitted on both sides, without any arrangement for releasing the brake from the side opposite to that from which it was applied. This is, of course, a great simplification, though it is not a complete solution, as it is often necessary to release the brake while the vehicle is in motion. The Great Western has, however, gone further than this, and has several thousand wagons fitted with an apparatus, which allows the brake to be applied or released from either side indifferently. In the Great Western either-side-brake the brake levers on either side of the wagon work on to the same shaft. The brake is applied by depressing one of the brake-levers, and held by a catch, which engages in one of a series of teeth—in much the same way, in principle, as with an ordinary wagon brake, though the details are different. The brake-levers are connected to the brake rigging by a loose joint, which enables the levers to be raised without any corresponding movement of the rigging. This upward movement of the lever is utilised to work a trigger, and the brake is released by the trigger mechanism knocking up the catch by which the brake is held on.

One of the means adopted of late years to secure the more economical working of the goods traffic has been the system of transferring goods from one vehicle to another at certain large centres, instead of despatching them straight to their destinations in the first instance. In this way parcels of goods travel for a part of their journey in wagons which also contain consignments for other destinations, and more can, therefore, be loaded into one wagon than would otherwise be possible. Among other large centres on the Midland, where this system is practised, is Leeds, where the goods station is also interesting in other ways, being, as it is, large and of modern design.

The station is a rectangular building containing six lines of rails (numbered 1 to 6), arranged three and three, with a platform down the middle, and two more platforms beside the outside lines; at the two outside platforms the drays draw up and consignments for or from the town are loaded on to the drays, or unloaded from them. Traffic from the north is dealt with at one side of the station and from the south at the other.

At Leeds, too, besides handling goods in transit, the Midland carries on a warehousing business. Above about half of the station there is a large warehouse in two floors, reached by a lift. A great part of this is let by the year to firms who find it a convenient spot to store their goods.

The day is divided into two unequal parts, the time from 4 p.m. to midnight being utilised for despatching goods, and the rest of the day for receiving goods for Leeds, and for transferring from one vehicle to another goods which have arrived for destinations beyond Leeds. As the trains arrive, as many wagons as there is room for are backed into the platform lines, and, as they are unloaded, each consignment is identified by the checker, and, if destined for delivery in the town, wheeled away by a porter to that part of the platform at which is drawn up the dray, which will serve the district in which the address is situated. If, on the other hand, the consignment is to be sent on by rail, the porter wheels it straight to one of a number of wagons marked for various destinations, which stand near at hand all day at the end of the same, or of another, platform; and the consignment is straightway packed in the vehicle, in which it will continue its journey, either to another transfer station or to its final destination. In this way small consignments of goods, which reach Leeds from all directions, are united to form considerable loads as they continue their journey.

The successful working of this system depends, of course, very largely upon an accurate knowledge of the geography of the line, the routes followed by the different trains, and other particulars, and is a system which is calculated to show better and better results the longer it goes on and the longer the men who work it have spent in mastering the rather complicated details. At Leeds, certainly, the system makes it possible normally to despatch a large proportion of wagons with full loads.

The moment a wagon has been fully loaded, it is drawn forward by a rope worked from a hydraulic capstan to a traversing table, which quickly carries it across to one of the centre lines of rails Just as the traversing table is about to reach its proper position over this centre line of rails, a short, stout pole is placed slantwise with one end on the ground and the other under the body of the wagon, so that the latter is slightly lifted, and at the right moment tumbles forward off the traversing table on to the rails, along which it is run out of the shed, to be sheeted and subsequently marshalled in the train, of which it will form part. The whole operation is very rapidly performed. When any movement of wagons is about to take place, one to six blasts on a horn are blown as a warning signal, the number of blasts corresponding to the number of the road on which the movement is to be made. As the supply of empty wagons becomes exhausted, more are brought into the shed along the centre lines of rails, and so work proceeds till. by 4 p.m., all the receiving and transferring for the day is over, and attention is turned to the purely outwards traffic.

The work of checking is, of course, greatly facilitated if all the consignments received are fully and legibly addressed. This apparently simple requirement, after having been a matter of dispute between the railway companies and their customers for a very long time, has now been accepted by the traders, and little trouble on this score is now experienced. It is probably the better understanding now existing between the different companies that has enabled them to carry the day in this matter, in which they would certainly seem to have reason on their side.

The covered-in station is only a comparatively small part of the space occupied by the company, which includes marshalling sidings, sidings for the storage of empty wagons, a platform where station to station traffic is dealt with, and stables for the 130 or so horses which are required to deliver and collect goods in Leeds. The company evidently find that it pays not to stint money on the horses. As a result of paying a good price for them, keeping them in large airy stables, and looking after them well, there were at the time of my visit only four horses unfit for work, and this in spite of the singularly uncompromising cobbles with which the streets of Leeds are mostly paved. A smithy and a harness-maker's shop form part of the permanent establishment. Although one-horse drays are the vehicles normally in use, means have to be provided for harnessing any number of horses, up to eight, to one vehicle, when exceptional loads have to be moved. If, as occasionally happens, a load is offered for which eight horses are insufficient, a traction-engine is hired for moving it.

The stricter attention devoted to the economical loading of goods trains has been followed in some cases by the introduction of an elaborate system of controlling from a number of convenient points, and through them, if necessary, from a single central office, all the goods traffic passing over a railway. This system, first applied by the Midland, has since been adopted with variations by a number of other companies.

On the Midland at the present time the supreme control over the goods traffic of the whole line is exercised from an office at Derby. The Midland is divided into eighteen districts, and these in turn contain from three to five sections, into and out of which the movement of every goods train is recorded by certain signal boxes, known as "reporting boxes," which are situated on the boundaries of the different sections. Every reporting box is in constant telephonic communication with the control office, in whose district it lies, and every hour it sends in a list of trains which have passed into the section of line, at the entrance of which it stands, but have not yet been signalled from the next reporting box as having passed out of it. This list is telephoned on to the head control office at Derby. Here a record of the position of each train in the five most important districts, between Normanton and Leicester, is kept by means of an arrangement devised for the purpose (the traffic of the other districts not being followed quite so closely). Strips of metal are fastened edgewise to a long table, each representing a line of rails; the positions of the various reporting boxes are marked at intervals. On the different reporting sections are arranged clips showing the approximate positions of all the goods trains in that section when the last report was received, and to each clip is attached a card of the colour which corresponds to the train reported (white for mineral trains, pink for express goods trains, and red for certain other descriptions of trains); on the cards also are inscribed particulars of the train, such as the number of the engine working it, the number of wagons it contains, its starting-place, destination, and the time at which it was due to begin its journey. At the edge of the table there is also an elaborate plan of the railway, showing the particulars of the line much more exactly than the metal strips can do. With the help of all this the operators have before their eyes a fairly complete representation of all the goods traffic passing over the running lines; they know what traffic there is waiting to be moved at the different points *en route*, and can make the most expeditious arrangements for it; they supervise the distribution of wagons; and, if anything occurs to disorder the working of the trains, they at once become aware of it, see the best way to set it right, and send off by telephone the necessary instructions. If a line becomes blocked, they decide what measures must be taken to work the traffic by an altered route, and they know when each engine-crew came on duty, and take steps to provide relief for them at the proper time. Any decision, which affects the traffic of more than one district, is always referred to the head office at Derby, but the district control offices issue instructions on their own account with regard to traffic, which neither passes out of, nor affects, any district but their own.

Certain categories of specially important goods trains, besides being reported in the same way as all the other goods and mineral trains are reported, are followed carefully throughout their whole journey as they pass the different signal boxes, and, if they arrive at their destinations appreciably behind time, investigations are at once made to determine the reason and to prevent it from occurring in future. And not only is this system used to prevent delays on future occasions, but, more than this, if it is found that a train has lost time early in its journey, arrangements can sometimes be made with the signal boxes ahead to keep the road clear for it at the proper time, and so help it to make up part, or all, of the time it has lost.

Another matter which is regulated from the central control office is the supply of wagons of special design, used for certain exceptional kinds of loads, which are despatched but seldom. The Midland has a small number each of about thirty kinds of wagons, which are designed for the transport of special kinds of goods, and it may easily happen that the available supply is insufficient to meet every sudden demand, so that some customer or other has to wait his turn. So, to minimise delays, a record is kept in the control office of the place where, according to the latest advices, each of these vehicles is to be found. This is done by the means of a board divided into a number of columns, each column being devoted to one kind of vehicle. In each column is a line of pegs, one representing each station where the vehicles, when empty, are laid up, and the pegs are kept ticketed with the number of vehicles reported to have arrived at each station.

The control system has resulted in considerable economy both of labour and rolling stock. The weak points of any scheme of working soon become apparent to any one who thus secures such a comprehensive view of it, and the elimination of either permanently, or temporarily, unnecessary trains becomes a simple matter.

To ensure the smooth working of the control system, it is of importance that the trains should be correctly reported. For this reason, therefore, there are displayed on the sides of the brake-vans, in large letters, certain code signs, which indicate the identity of the train—its time of departure from its original starting-point and its destination. The rather ugly large figures, too, with which Midland engines are now numbered, play their part in making it almost impossible to misread the number of the engine.

At Toton, a couple of miles north of Trent, are situated the marshalling sidings, from which are distributed the enormous quantities of coal raised in the numerous neighbouring collieries. The sidings lie on either side of the main line to the north, those to the east dealing principally with full wagons coming from the collieries, and those to the west with the empty returning wagons, and in both cases the marshalling is performed by the help of gravity. In other parts of the country a special undulation, known as a "hump," has had to be built in order to make the force of gravity available, but at Toton the trains of wagons from both directions arrive at a level high above the sidings destined to receive them, and there is no necessity to push them laboriously up one side of a hill to make them run down the other side. Some idea of the volume of the traffic dealt with may be gathered when it is stated that there are 30 roads parallel to one another to the east of the main line and 18 to the west, and, even so, trains are despatched to many more destinations than there are roads on which to make them up. The system of working is that a train arrives on the high level, the train engine is detached, and then, when it is the turn of this particular train to be broken up, a shunting engine comes on behind and gradually pushes it over the brow of the hill; here at first, for a short distance, there is a steep descent, on which the wagon rapidly gains speed, and subsequently, right to the end of the siding, the descent continues, but much less steeply, so that a wagon, which runs normally, will, when properly started, continue in motion for any distance, but one which has been brought to a stand will not start again of itself. The wagons are run down the hill, either singly, or, if more than one for the same destination are already next one another, these are sent down together. The work is done very quickly, sometimes only 20 yards separating one shunt—as each wagon or number of wagons is called—from the next. The points are set for each shunt, in accordance with marks placed upon it, and are controlled from a box near the divergence of the different roads. All wagons do not run equally well, some being better maintained than others; frost may harden the lubricating grease and make them run stiffly, and wind exercises an accelerating or retarding effect, in accordance with its direction; so the incline, on which the wagons acquire their momentum, must be made steep enough to give an unnecessarily great impetus to a wagon which runs freely, and its course may have to be retarded. At the bottom of the steep part of the incline, therefore, stand shunters, armed with poles, and, as each wagon passes them, they observe whether it is going too fast; if it is, one of the shunters puts his pole between the brake-lever and the frame of the wagon, and, lifting his feet from the ground, rides on the end of the pole, till he judges that the speed has been sufficiently reduced. Sometimes, but very rarely, a wagon runs so badly that it has not enough momentum to carry it to its appointed position; in this case it is usually necessary for the pushing engine, when next it is disengaged, to descend the incline and take the wagon to its proper place.

In this way the different trains are made up, but before they can start on their journey a certain amount of subsequent shunting is generally necessary to get the wagons in the right order. This is done in the ordinary way by the awkward process of the trains being run backwards and forwards by an engine, and offers the greatest contrast to the simple and expeditious method of making up the trains by the help of gravity. When a train is arranged with the wagons in the proper order, a brake van is run down by gravity from a short siding, where a number of these vans are standing in readiness, and attached to the rear, and then everything is ready for the start. Some of the trains leaving Toton for the south are very heavily loaded. One, which starts in the afternoon, sometimes loads up to eighty full wagons, and is drawn by two engines. The day I was there, there were 71 loaded wagons, and, even so, the procession seemed endless. To relieve the main line, there is, as far as beyond Trent, a loop, by which most of the traffic to and from the south leaves and enters the Toton sidings, and this loop adds another to the very large number of lines, which cross and connect with one another round about Trent.

The immense traffic worked in and out of Toton, and the marshalling and shunting operations, which are there carried on, call for a large number of goods and shunting engines, which are stationed in sheds towards the north end of the yard. The greater

TOTON SIDINGS.

number are of ordinary British 0–6–0 designs, but there are still at work a number of 2–6–0 engines, ordered in America some twelve or fifteen years ago, at a time when a sudden rush of traffic made it impossible to secure in this country all the engines required. The American engines, although naturally not quite so well suited to their work as their British sisters, are still, after so many years, giving fairly satisfactory results, and it seems likely that their useful careers will be prolonged for some time to come.

Like most other British railways, the Midland has spent large sums for providing facilities which have no necessary connection with actual railway transport. In no part of the world do the railways confine themselves to the business of transport by rail. In undeveloped countries they sometimes practically administer whole provinces, and are directly concerned in almost every form of activity there prevailing. Though in settled countries the relative importance of railways is not so great, they invariably extend the field of their operations to a greater or less extent outside the mere working of their lines. They provide road transport to carry passengers and goods to and from their trains, hotels for the accommodation of passengers, and warehouses for goods, docks and harbours to give connections between their trains and sea-going vessels, and, very often too, lines of steamers of their own. In Great Britain they also, as a rule, manufacture the greater part of their own requirements in their own workshops. British railways are remarkable among those in settled countries for the extent to which they have carried their outside activities, and, not unnaturally, in a sea-girt country like

Great Britain these activities are primarily in connection with the sea. It is manifest that a concern, which possesses railways on land, vessels on the sea, and docks and quays to connect the two, is in an extremely strong position for keeping in its own hands any traffic that it may once secure. British railways have not only done their best in this manner to secure and keep for themselves existing traffic, but have shown great enterprise in developing new routes. There is hardly a railway of any size in Great Britain which does not, either directly or through a subsidiary company, possess a considerable fleet; all the more accessible ports of the coast of Europe are served by the steamers of some railway company or other; four of the biggest railways run their own steamboat services between different points in England and Ireland; and, if the railways have no actual share in the ownership of the great ocean lines, the North Western and the South Western stand respectively in very close relation to the shipping interests of Liverpool and Southampton.

The Midland service from Heysham is quite a recent addition to the railway steamship services between England and Ireland. So far Heysham is, perhaps, more deserving of attention for its promise than for its performance, as is generally the case with any large enterprise during the first years of its existence. A daily service to and from Ireland, summer sailings to and from the Isle of Man, and the custom of a certain number of tramp steamers, are only the beginning of what is likely one day to be a very big business. Meanwhile, the place is being got into thorough working order. Difficulties with regard to the silting up of the entrance, owing to the strength of the currents in Morecambe Bay, have been very largely overcome by the construction of a new pier, and now a small amount of dredging suffices to keep open for large ships the short channel which connects the entrance of the harbour with the so-called Heysham Lake—extensive deeps through which the approach to the harbour is made. The company's vessels are in constant communication with the shore by means of a wireless telegraph station at Heysham. All the lighting and power required for the harbour is supplied from the company's power station near by, which serves also to provide electricity for the working of the experimental electric train service between Heysham, Morecambe, and Lancaster, which has now been in existence for some years. But the great day for Heysham will be when docks have been built over the large area of flat, low-lying ground, which the company possesses adjacent to the harbour, to be, if necessary, supplemented by yet a further series of docks, to reach which a cutting through a low ridge will be required. And the present delay has been not wholly without compensation, for it is now realised that, owing to the great increase in the size of steamships during recent years, the principal dock entrance, which was originally planned to be 80 ft. wide, will have to be made 100 ft. wide, and corresponding increases made in the dimensions of the docks.

Next to their shipping activities British railways have endeavoured to secure for themselves as much as possible of their clients' custom by building and maintaining, at important centres, hotels, which, being generally on the actual sites of the stations, offer those people, who make use of them, the maximum convenience. A big modern station seems hardly to be thought complete without a huge hotel in close connection with it to intercept as much as possible of the expenditure of the rail-farers for the benefit of the railway company's shareholders. Nearly all the London termini have more or less big hotels attached to them in this manner, most of the big English provincial towns have at least one big railway hotel, which is sometimes the most important public building in the place, and, crossing the border, the provision of hotels in Glasgow and Edinburgh, by the different railway companies, is found to be on a completer scale than perhaps anywhere else. The hotels at the Central, St. Enoch's and Queen Street, Waverley and Prince's Street, what would modern Glasgow and Edinburgh be without them? In England the hotels owned by the Midland are certainly among the best managed of all. They pass that crowning test of efficiency for British hotels that the coffee which they supply is, almost always, not merely drinkable but excellent.

Some railways build more of the rolling-stock and appliances which they require than others. On most lines there can be very little modern rolling stock that did not come from the owning companies' workshops, while even those railways, which give out more of their work to private builders, still manufacture for themselves by far the greater part of their requirements, and have recourse to outside assistance only when their own hands are full. The big British railway companies employ private builders much less than is the case in any other country, and possibly it is owing to this that the rolling stock, particularly the locomotives, of most of these companies exhibits such marked signs of the individuality of the designers. But, though there is little standardisation on inter-company lines, each company has in its own workshops brought the standardisation and interchangeability of parts to a high pitch of perfection.

If the railways are ever taken over by the State, everything to do with them will certainly be in a large measure standardised throughout the country. A central authority, managing the railways as a whole, would not hesitate to put a stop to certain existing anomalies which are the outcome of the present system, and which do no good to any one. It is certainly not good management that the Scottish trains on the East and West Coast routes should have to be fitted with both Westinghouse and automatic vacuum brakes because the northern companies have adopted the former, and the southern companies the latter, system.

Then, in the manufacture of rolling stock and appliances generally, much fewer patterns, produced in much larger quantities than is at present done, would perhaps conduce to economy. But it is doubtful whether more would not be lost than gained by such means. It is obvious that when the railways are, as at present, divided up into a number of different concerns, each of which has, to some extent, its own type of appliances, there is far more scope for the introduction of improvements and developments of all kinds than if all the appliances for the railways throughout the country were produced under the supervision of a single authority. As already remarked, each railway has to a very large extent standardised the appliances which it requires for its own use, with very satisfactory results as regards economy, and it seems quite likely that this process has already been carried far enough, and that the introduction of a more rigid standardisation of railway appliances would act as a most undesirable check upon invention. It is also quite possible to overrate the value of standardisation. One reason why it is so much cheaper to build things in batches than singly is that one set of drawings and patterns suffices in both cases. There is no doubt that it is much cheaper to build twenty engines or carriages of the same design than it is to build one, because the cost of making the drawings and patterns is the same for the one as for the twenty. But this cost, when spread over only twenty units, may not amount to very much per unit, and a point is soon reached when the economy, which can be secured by using the same drawings and patterns, becomes quite small.

It is extremely difficult for any one unconnected with any given railway to secure a trial upon that railway for any improved appliance. Epoch-making inventions like the injector, the Westinghouse brake, and the superheater did not make good their position without a struggle. Walschaerts' valve gear is even now being only tentatively applied. Such improvements as are from time to time adopted, are generally the inventions of a designer or designers already in the service of some railway or other. It is, therefore, highly desirable that the number of such persons should be as great as possible, and, if the designing for all the railways were done at one central office instead of at a large number of offices situated in different parts of the country, as is now the case, their numbers would certainly be considerably diminished.

A rather serious objection to the way in which the railway workshops are conducted has lately been a good deal discussed, and this is that no adequate figures are made public, by which the cost of the manufactures of these shops can be compared with that of the manufactures of private firms. The inference is that the railway companies, as manufacturers, not being obliged, so as to secure orders, to compete with other manufacturers in the open market, carry on their work on uncommercial lines, and do not keep either their methods or their equipment at such a high level of efficiency as do the private firms. To what extent the so-called "open market" in the railway material industries is really open, that is to say to what extent the various firms abstain from making private arrangements with one another when preparing to tender for orders, I do not know. It is certainly more than possible that they contrive to shelter themselves from the full effects of unlimited competition. But, be this as it may, the prices which they charge are known and available for comparison, while the cost of the railway companies' own manufactures are not known in anything like the same detail. To some extent, however, this is unavoidable because the railway companies' establishments are necessarily repair shops as well as works for the construction of new material, and to that extent the conditions are different from those found in the establishments belonging to private firms.

A good many years ago it was established by a decision of the Courts that railway companies may not manufacture for one another or for the general market, but each must confine itself to meeting its own requirements. To such a point do the companies now do their own manufacturing that the private firms, which make rolling stock, appear to regard this decision as the only thing which preserves to them any part of the home market, and they look with disfavour on proposals for amalgamating separate railway companies because they fear that the combined companies, by joining their productive resources, will be able yet more completely than before to dispense with outside assistance. But if the railway companies carry out for themselves a great many of the later processes of manufacture, they are very far from monopolising the earlier processes, and practically everything they use has, by the time it reaches them, had a good deal of work already done upon it. It is noteworthy that with regard to rails, the making of which is a fairly simple process, the railway companies, except the North Western, do not manufacture for themselves.

The fixing of rates and fares is the most important and also the most difficult question connected with railways. Owing to the enormous part railways play in present-day life, and the almost absolute dependence which everyone is obliged to place upon them, any unfairness in their charges must have the most serious results, while at the same time the number of different considerations, which have to be borne in mind in endeavouring to decide what constitutes fair charges, make the problem one of the greatest difficulty. It is clearly out of the question to attempt to fix fares in accordance with the actual expense incurred by the railway company in transporting each passenger. Hardly two consecutive miles of any railway have cost exactly the same sum to build, the prices of different kinds of engines and carriages vary, the railway companies' profits vary with the number of passengers carried in any particular train, and with the number of trains run over any particular line, and so on. Then there are questions of public policy to be considered. A railway, being a State sanctioned monopoly, cannot be left free to fix its charges in the same way as a private business can be left free. Many branch lines in remote parts of the country, without much traffic, must be sources of very little profit to the companies, but the railways may not try to recoup themselves by charging specially high fares on lines of this kind, as this would inflict special hardships upon the people who use them, and, it is considered, would conflict with the duty of the State, as far as possible to ensure that none of its citizens are subjected to special disabilities. On the other hand, it is of great importance to enable workmen, whom modern conditions have forced to live in localities remote from their places of work to go backwards and forwards at very cheap fares. Railways, as well as other concerns, can afford to give a reduction on a quantity, and the cheapness of workmen's tickets is to some extent compensated by the great numbers of workmen who travel. But besides workmen, many other kinds of passengers get the benefit of this principle to a greater or less extent. Chief among these are the season-ticket holders, who, if they travel a great deal, get very large reductions on what they would have had to pay as ordinary passengers. Railway companies love the season-ticket holder. He is often a man of substance, whose living on the line means much more profit than his own season ticket brings, he travels at regular, and, therefore, convenient, times, and, once firmly established on the line, is likely to remain there. Do not the Chairmen revel in him at the general meetings? However blue otherwise the complexion of the report, the number of season-ticket holders has generally gone up, and, as it is settled beyond doubt that these same season-ticket holders are the barometer of the prosperity of the line, all is well even on what would otherwise be the most depressing occasions.

So, hardly any attempt is made to fix fares in accordance with the expense incurred in building the line, the ordinary fares being almost always exactly in proportion to the distance, but the principle of granting a reduction on a quantity is met with in a variety of forms. Beginning with a small reduction on the double fare in the case of most return tickets, the principle is carried to greater lengths in the matter of week-end tickets to certain selected places; excursion tickets, issued when large numbers of people may be counted on to travel in a manner which makes their transport very economical, are cheaper yet, and tickets for workmen's trains, when the conditions of excursion trains are reproduced in a higher degree, probably cheapest of all.

As so few people have any money to spare, it is always found that the great bulk of travellers gravitate to the cheapest class. The only really effective way of preventing practically the whole travelling public from utilising the cheapest class is to abstain from running carriages of this class on fast trains. In England this measure is very little adopted, and railway managers have long had to face the problem of what to do with the first and second-class carriages.

The Midland long ago abolished second-class carriages, and this example has been followed to a very large extent by other companies, so that gradually the second class is being crushed out of existence, but the problem of the first class is a different matter. It is recognised that some means must be provided for people, who desire it, to secure, by the payment of a higher fare, a greater degree of comfort and privacy than is afforded by an ordinary third-class carriage. The only real questions appear to be how much extra fare is to be demanded, and how the extra comfort and privacy are to be provided. The principal objection to the present arrangement is the great difference existing between the first- and third-class fares, which to the minds of most people is far greater than the difference in the accommodation given in the two classes. But, as the cost to the railway company must be approximately in proportion to the space occupied by the passenger, and a first-class passenger gets nearly twice as much cubic space reserved for him as a third-class passenger, it would be necessary, if first-class fares were much reduced, to effect also a reduction in the space offered, which would seriously diminish the already too small attractiveness of the first class.

At intervals very faint protests are raised against the British system of not registering luggage when it is conveyed by train. As the protests never seem to attract any attention worth speaking of, it looks as though most people were quite satisfied with the present arrangement, which is certainly rapid and convenient, and, although luggage is theoretically more likely to be lost or stolen if it is not registered, the extreme rarity with which anything of this kind happens in England effectively disposes of the fancied advantage of registration from this point of view. Practically every other system, indeed, adds seriously to the trouble of a journey at each end, and, even if registration, as practised on the Continent, makes it slightly less likely that the luggage should get lost outright (which, moreover, is very doubtful), it is only necessary to read the correspondence columns of the newspapers to be speedily convinced that it is very far indeed from preventing thefts from taking place *en route.* In America, if a traveller is so unwise as to be travelling with his own luggage, the difficulties of securing it on arrival at his destination are often considerable, and if the arrival takes place late at night, the chances are that he will be told that he cannot have it at all till the following morning.

If the fixing of passenger fares is a complicated matter, the complications encountered in fixing goods rates are greater still. From the point of view of a railway company, one passenger is very much like another—each passenger finds his own way to the station, buys his own ticket, gets into the train by his own motive power, when there occupies the same amount of space as each of the other passengers of his class, and at the end of the journey alights of his own accord and goes about his business. But with goods it is very different. A consignment may weigh a few pounds or may want a whole train to convey it; it may, or may not, be perishable and require to be sent off and delivered at express speed, it may want special care in loading, transit, and unloading, it may have to be sent in specially constructed vehicles, and it may be packed in a manner easy to handle or the reverse, and so on. The trouble and expense, therefore, involved in transporting equal weights of goods varies within far wider limits than is the case with passengers, and goods rates are naturally graduated far more finely than are passenger fares, while the principle of granting a reduction on a quantity is yet more firmly established.

For the purpose of charging rates, goods are divided into eight classes. For the first 20 miles the rates on goods belonging to each of these classes vary from 1*d.* to 4·30*d.* a ton a mile ; if the distance exceeds 20 miles, the rates per ton per mile for each of the next 30 miles are somewhat lower ; if the distance is more than 50 miles, the rates for each of the succeeding 50 miles are lower still, and they are lower again for each mile beyond 100. (These rates do not include terminal fees, fees for loading, unloading, etc., nor, in the case of the lowest rates, the use of wagons.) They are, in each case, the maxima that can be charged by law, but these maxima are by no means always charged in practice. Moreover, very large numbers of things, in which there is a considerable traffic, are given special rates lower than the class-rates which they would otherwise be called on to pay.

This scale of rates effectually prevents the railways from making charges higher than are therein authorised. But, up to the time of the passing into law of the Railways Bill of 1913, it was not held that the companies had the power of increasing up to the maximum limit, or indeed at all (unless there were very special justifying circumstances) any existing rate lower than the maximum, and very few increases were in fact put into force. Under the Act of 1913 the railways now possess this power, but may use it only to recoup themselves for expenditure incurred in raising the wages and improving the conditions of service of the railway servants.

Any experimental reduction of rates on British lines is therefore very difficult, owing to the fact that, if the reduction fails to produce the hoped-for effects, and it is desired to put the rate up again to its former level, the railway company may be called upon to justify the increase before they put it into force.*

Besides all this, railway rates have been fixed with due consideration for "what the traffic can bear." That is to say, certain luxuries and articles of considerable value are quite frankly called upon to pay more than the actual cost of their transport, together with a fair profit, would amount to. This is to some extent a matter of public policy. It is manifest that, if goods of this kind are obliged to pay more than their share, other kinds of goods need not pay their full share, and, if these other kinds comprise the necessaries of life, the cost of living may thus be artificially cheapened. From a purely economic standpoint such

* This has not, however, prevented the North Eastern from putting into operation for certain mineral traffic a sliding scale of rates, which appears to work well and give satisfaction. The rates rise and fall automatically, according to whether the trade in the minerals concerned is good or bad. The North Eastern, which has its own district to itself, no doubt has facilities for making experiments, which other railways have so far not possessed. Sliding scales of rates are, however, so obviously fair that other companies might well consider whether, now that common action has been so much facilitated by the agreements with one another into which they have lately entered, it might not be possible to introduce a considerable number of rates arranged on a sliding scale. Such a step might just possibly be followed by a sliding scale of wages for the railway servants, and railway finances in this manner assimilated somewhat more closely to the financial conditions, which obtain in the great organised trades.

a state of affairs is no doubt deplorable, but certainly it has played some part in the fixing of rates.

Rates, again, are frequently arranged so as to increase the area whence supplies are brought to a given centre. To effect this, the rates on commodities despatched to this centre are often very little more, if they come from great distances, than if they come from comparatively short distances—the difference in the rates is, at any rate, much less than the difference in the distances. As the actual transport—apart from terminal expenses—must cost the railway a sum more or less proportional to the distance traversed, there can be no doubt that the commodities which come from furthest off receive in a manner preferential treatment, but, the area of supply being increased, the consumer gets a greater choice, and in this manner the public interest is served.

These are perhaps the most important general principles on which rates are fixed. But beyond them a great many factors come into play, and rates have to be determined upon a close consideration of all the facts of any given case.

A discussion, which is constantly arising, is upon the question whether the railways, in order to secure the carriage of goods, which they would otherwise not get at all, are justified in carrying them at rates lower than those at which they carry the same sort of goods, which must in any case pass over their lines. If it is a question of utilising the rolling stock for a very small return, or leaving it idle, it may be more profitable for the railway to accept very low rates indeed, in order to earn something on its capital, instead of nothing. And as, by hypothesis, if the railways did not grant the low rates, rates equally low would be granted by some other means of transport—for instance, steamers—it can hardly be contended that the goods in question receive, in this manner, unduly favourable treatment.

The principle of giving reduction on a quantity has often led to very bitter complaints against the railways on the part of persons who fail to supply large consignments, or who are refused a reduction because they deliver their consignments to the railway company in such a form that only a comparatively small amount can be transported in each vehicle used. To judge from the newspapers, complaints in regard to the rates charged on British railways for the carriage of farm produce are more frequent and bitter than those in regard to anything else. It is said that foreign farm produce gets the benefit of rates so much lower than those granted to British produce that the former receives an undue preference in the markets of this country. In vain do the railways point out that, if the British farmers would supply consignments as large as those coming from abroad, and packed in a way which would enable them to load a wagon to its full capacity, there is absolutely nothing that would cause them so much pleasure as to give the British producer rates as low as those of which the foreign producer receives the benefit. Apparently, the British producer will neither pack his goods in such a manner as to make them easy to handle, nor join with his neighbours in providing large consignments. The farmers go on complaining of the rates and the railways go on complaining of the obstinacy of the farmers, and there at present the matter seems to rest. It is, perhaps, possible that there is sense on both sides. The position of the railways is certainly clear and intelligible, and it is by no means unlikely that the British farmer gains more by avoiding the expense of elaborately packing his goods, and by being able to send off small quantities at any moment he finds convenient, than he loses in the extra railway rates. But, under the circumstances, he cannot reasonably expect to receive the benefit of the same rates as apply to foreign goods, which are forwarded under conditions much more onerous to their consignors.

Owing to the policy, which has been pursued in England, of allowing a railway to be built anywhere, where a reasonable demand existed, by any one who would undertake to do it, the number of different companies, which have come into existence, is very great. Many of them have gradually been absorbed by the bigger companies, but a large number of minor companies still exist, of more than a few of which most people do not know the names. And this is not all, for the lines worked by the larger companies comprise many sections built, and still owned, by independent companies, and there are also the numerous lines owned jointly by two or more of the big companies. Over nearly all these the traffic is given through rates and fares, which have to be apportioned between the various companies, which own and work the different lines. This apportionment is a work of great complication, and, to carry it out, a central body, independent of all the beneficiaries, becomes practically a necessity. The body on whom this gigantic labour falls is the Railway Clearing House, an institution which has grown up with the railways themselves, and, perhaps for this reason, performs its work with such mathematical precision as to give its clients the nearest approach to complete satisfaction.

The question of the development of canal traffic has in recent years come very much to the fore, and a Royal Commission, whose report has lately been issued, was appointed to investigate the matter. Many people are under the impression that, if canals were properly developed, they would at least provide a means of transport for minerals and non-perishable goods consigned in bulk much cheaper than railway transport. In various Continental countries canals are much more highly developed than they are in Great Britain, and a large proportion of the traffic of such countries as France and Germany is carried over the inland waterways. It must not be forgotten, however, that the natural facilities for inland water-borne traffic are in many parts of the Continent much greater than they are here in Great Britain, owing to the existence there of great navigable rivers, and to the flatness of large areas of country, which makes the construction of canals easy, and much reduces the difficulties of keeping them supplied with water. Instead of navigable rivers, nature has provided Great Britain with a much longer and more convenient coast line than her Continental neighbours possess, and this extra length of coast line far more than compensates for the very small amount of navigable river which she has. But, while Great Britain is naturally much less well suited than some other countries for the inland carriage of goods by water, a still more formidable obstacle to the development of canals is found in the conditions of trading which obtain in this country. To such a pitch of perfection have the railway facilities attained that the inland transport of commodities in bulk has been reduced to very small dimensions. Almost all commodities and articles of commerce are stored or warehoused in bulk at some large centre (very often a big port, whither they have been brought by sea, either coastwise or from foreign countries), and the smaller points of distribution throughout the country are kept supplied from these large centres with small consignments sent off exactly as they are wanted by trains travelling at considerable speeds. Now, canal transport is necessarily slow and best suited to the transport of goods in bulk—*i.e.* it is just the opposite of what British traders have grown accustomed to—and any considerable increase of canal traffic would have to be accompanied by a change in the conditions of trading which are now current. This must obviously be so difficult to effect that, unless some great economic advantage could confidently be looked forward to from increasing the amount of canal traffic, it would probably be better to spend any money that might be available upon further development of the railways in preference to spending it on canals.

The peculiar conditions, under which British goods and mineral traffic is carried on, are borne witness to by the design of the standard British goods engine. By far the greater part of the long-distance goods and mineral traffic is worked by engines of quite moderate power, with 6 wheels, all coupled, and designed in such a way that they can be run safely at fairly high speeds—they have a comparatively long wheel-base, a short overhang at either end, and inside cylinders. In recent years some British railways have adopted a certain number of 8-coupled engines, but the Midland, which probably has the largest mineral traffic of any British line, still works it all with 6-coupled engines. Very different is the case on the Continent and in America. On the Continent 8-coupled engines were common from very early days, and now the heaviest trains are worked by 10-coupled engines, while engines with two groups of 6-coupled wheels are not unknown. In America there has of late years apparently been a sort of competition between many of the principal railways as to which should build the biggest engines, with the result that, in order to make the engines bigger and bigger, more and more wheels have been added, till some of the latest specimens rest on 24 wheels and weigh something like 250 tons without the tender.

0-6-0 GOODS ENGINE, MIDLAND RAILWAY.

CHAPTER III

THE WEST COAST

The Engines of the Caledonian Railway—Speed of Passenger Trains—Performances of the Engines of the Chemin de fer du Nord—Water Troughs—Compound Engines—Frequency of Long-Distance Passenger Trains—North Western Railway—Caledonian Railway—Docks—Coal Traffic—Glasgow Central Station—Highland Railway.

In the course of the last quarter of a century the engines of the Caledonian Railway have at various times been called upon to perform feats of so spectacular a nature that the successful accomplishment of these feats may be said to have opened new eras in the history of the locomotive. When considering the express train service of the Caledonian one is, therefore, inclined to think of this company as different from other companies, and to judge it according to a higher standard. The performances in 1888 of the single wheel engine, No. 123, were the foundation of the Caledonian engines' great reputation, and the fame of No. 123 may be matched with that of the Great Northern 8 ft. singles, and the old broad gauge singles of the Great Western. She had a leading bogie, driving wheels 7 ft. in diameter, and a small pair of wheels under the foot-plate, and inside cylinders. She weighed 42 tons, of which 17 tons were upon the driving wheels. The grate area was 17 sq. ft. At the time she was constructed the building of new single engines had almost ceased, and no engines of precisely her type had ever yet been seen. In 1888, a year or two after she made her appearance, the race to Edinburgh took place, and she was chosen to work the West Coast train from Carlisle to Edinburgh. The train was a particularly light one—about 80 tons without engine and tender—but only 112 minutes were allowed for the 100¾ miles, and on the way the Beattock bank had to be ascended. Now, of all the obstacles which British engines are called upon to surmount, the Beattock bank—10 miles, averaging 1 in 80, the last 6 of which are 1 in 75—is the particular one, which in popular estimation is held to impose the greatest test upon the locomotive, so that to put a single engine, which most people regarded as an obsolescent type of machine, to haul over such a road a train, to which the attention of the whole country was directed, was to place her in a position of such prominence that her success, if achieved, must make the deepest possible impression. And No. 123 succeeded. Day after day she performed the journey well under booked time, and, what was more, her uphill work was better than her downhill work. Downhill she does not appear to have attained any remarkable speeds, in spite of the existence of long stretches of favourable line, where she certainly could, if put to it, have attained very high speeds indeed. But it was uphill principally that she proved her mettle—she made light work of the Beattock bank, and then all the world rubbed their eyes and began to see that the single engine had been, perhaps, over-hastily abandoned. Looked at from this distance of time, and in the light of subsequent experience, the performances of No. 123, although certainly good, do not appear by any means so marvellous as they appeared in 1888. They were, in fact, just what might be expected from a properly designed engine of that sort, in the hands of a competent driver and a competent fireman. But, none the less, they made a profound impression, and, although, curiously enough, No. 123 was the only engine of her precise design ever built, she was the forerunner of a large number of single engines of the same general type, which were built for a good many of the principal English lines in the course of the next dozen years. Far more remarkable still, than the performances of No. 123, were the doings in 1895 (during and after the race to Aberdeen), and in 1896, of the four-coupled express engines. Taking everything into consideration, the main line of the Caledonian is more difficult than any other main line in Great Britain over which any 50-mile-an-hour trains are run—the gradients are exceptionally severe, and there are a number of places where speed has to be reduced from motives of safety. Yet it was the performances of the Caledonian engines over this line that first showed how 60 miles an hour, start to stop, could be achieved by an express train of moderate weight as reasonably as it had, up to then, been held that 50 miles an hour could be achieved. Remembering this, it must be confessed that the best present-day trains of the Caledonian are disappointing. There have been, it is true, in fairly recent times one or two trains a day timed to cover the exceptionally easy 32½ miles from Forfar to Perth in 32 minutes *; and over other lengths there are a certain number of runs

* As these trains used, till quite lately, to appear regularly in the statistical lists of fastest runs, I suppose they existed. They were quite unrecognisable in Bradshaw.

at between 50 and 55 miles an hour. And many of the trains are heavy, and there are, almost everywhere, the severe gradients to be faced. But, for all this, better things might be expected of a line, which has given evidence of possessing such exceptional enterprise when a great occasion arises to call it forth. Compare the timing of the best train to the Highlands to-day with what was done quite easily one night in July, 1895, in the earlier stages of the race to Aberdeen, when I happened to be travelling from Euston to Perth by the 8 p.m. train. The fastest existing train (7.45 p.m. from Euston) reaches Perth in 9 hours, with stops at Crewe and Carlisle only, and maintains an average speed of 49¼ miles an hour from Carlisle to Perth. The train of 1895, with an extra stop of 3 minutes at Stirling, reached Perth in 22 minutes less time; and this was long before the West Coast engines were being at all pressed. The North Western ran to Carlisle at quite a moderate speed, but the Caledonian engine, which then came on, ran to Stirling at an average start-to-stop speed of just upon 55 miles an hour, and thence to Perth at over 54; and, even so, the performances of engines of the same class a few weeks later, to say nothing of the work of the—only rather more powerful—"Dunalastairs" in 1896 showed how much she must still have had in hand. The "Dunalastairs," which astonished the world in their youth, still are there, and have been reinforced by numerous classes of engines of the same type, but more powerful and more perfect, to say nothing of the six-coupled machines, which are used for the very heaviest trains. And, if called upon to equal or surpass the doings of their predecessors, we may be sure that the Caledonian drivers of the present day would not be found wanting. Not long ago, indeed, I was able to satisfy myself that it is only necessary to provide an opportunity, and the Caledonian locomotive department will appear to quite as great advantage at the present time as it ever did in years gone by. On the occasion in question, one of the new 4–4–0 engines, fitted with a Schmidt superheater, was working the evening express from Aberdeen with the rather unusually heavy load of 335 tons (exclusive of engine and tender). The weight of engine and tender in full working order is 115 tons, so, making allowance for the fact that the tender's supplies both of coal and of water were partly exhausted, the weight of the two may be put at 100 tons; this makes the total moving weight 435 tons. The train is timed to run the 32½ miles from Forfar to Perth in 34 minutes. Forfar station, standing as it does, on a sharp curve, is rather an awkward place to start from, so it took some time to get into speed, but, when speed had once been attained, 18 miles of slightly undulating line, which is to all intents and purposes dead level, were run in 16 minutes 27 seconds, which is just 65⅔ miles an hour. Assuming the resistance of the train to have been normal, the engine must, all this time, have been developing about 1370 horse-power, which, for a machine of her size, is a remarkable sustained effort. It may further be noted that steam pressure was easily maintained all the time at about blowing-off point, no special preparations had been made, and the engine was at the end of a long day's work, so the performance must be regarded as one which she is normally capable of repeating whenever required. For the last 8 miles or so into Perth the line is on a fairly steep falling gradient. Here the good work continued, and, by the time the regulator was shut, preparatory to a rather slow stop at Perth, the speed had very nearly, if not quite, reached 80 miles an hour. (I timed $\frac{1}{2}$ a mile in $22\frac{3}{5}$ seconds, but did not get the intervening post. Half a mile in $22\frac{1}{2}$ seconds is 80 miles an hour.) The whole run was completed in a second or two less than 33 minutes.

The natural energies of the Caledonian locomotive department were originally put under restraint by the agreement, reached in 1896, which forbade the East Coast and West Coast trains to reach their destinations in less than such and such a time from leaving London, but at the present time the policy of the Caledonian management is to go even further, and very strongly to discountenance any acceleration of any long-distance train; and this they do, not merely because they are bound by an agreement, but also because they regard such acceleration as undesirable in itself, on account of the greater expense involved by higher speed, and the greater chances of unpunctuality, which they believe would exist. I venture to regard this policy (which is by no means peculiar to the Caledonian, but may, at the present time, be regarded as the accepted policy of nearly every railway in Great Britain) as a completely mistaken one.

If the character of the road and the speed alone are considered, and the size of the engine, on the one hand, and the weight of the train on the other, are left out of account, never since 1896 has there been any locomotive work in Great Britain to compare with that performed by the Caledonian engines in that year. The 8 p.m. from Euston was given 125 minutes between

(1)

(2)

CALEDONIAN RAILWAY: (1) 4-4-0 EXPRESS ENGINE; (2) SINGLE ENGINE, NO. 123.

Carlisle and Stirling ($117\frac{3}{4}$ miles), and not infrequently this run was actually performed at an average speed of about 60 miles an hour. Elsewhere isolated runs have been performed in better time, and more powerful engines with heavier trains have exerted much greater horse-power ; but, for high-speed work, done day after day, over difficult road, these performances stand unique. The next most remarkable regular work that has been seen in Great Britain was probably that of the best Leicester and Sheffield trains on the Great Central, which, over a road much easier than that of the Caledonian, used for a time to maintain unusually high speeds for long distances together. But this also has long ceased. The nearest approach to the old Caledonian timing that now exists, over a road at all comparable in difficulty, is the South Western's run (suppressed from October, 1912, but re-introduced in July, 1913) of 88 miles from Salisbury to Exeter in 96 minutes. But, to equal the actual work of the Caledonian engines in 1896, the South Western would have from time to time to perform this run in from 87 to 90 minutes. My own experiences over the length in question certainly do not lead me to suppose that this is ever done. In Great Britain, indeed, for the last seven or eight years, there has been a complete dearth of any really remarkable performances in the way of long-sustained high speed, and this in spite of the fact that during that period there have been built a very large number of engines, much more powerful than those previously in use. Some very remarkable work in the way of hauling extremely heavy trains at fair speeds is from time to time recorded, but when, as is even now constantly happening, one of the biggest engines gets a light train, or one of moderate weight, no attempt is made to utilise her great power to attain really high average speeds.

My own experiences, as regards high speed work in Great Britain are, I say with deep regret, of the most dismal kind. Circumstances prevented me from ever travelling behind the Caledonian or Great Central engines during the comparatively short periods when the speeds of these lines were at their zenith, so, no doubt, I entirely missed the greatest opportunities. As it is, on only one occasion on a British railway have I ever taken part in a start-to-stop run at over 60 miles an hour, and this was not till 1912, when a slip-carriage, in which I was travelling, came to a stand at Westbury 58 mins. 41 secs. after the train, to which it was attached, had left Reading, 59½ miles away. As regards maximum speed, only about three times have I ever in Great Britain noted an undoubted speed of 80 miles an hour, and my best sustained burst of high speed was as long ago as 1897, when one of the smaller Midland singles, with a train of about 120 tons, ran 10 miles downhill, between Leagrave and Bedford, in 7 mins. 40 secs.—78¼ miles an hour. Perhaps I have been unfortunate in my experiences, but anyhow I cannot regard what I have seen as other than a meagre result of twenty years' fairly close observation of the working of the trains in which I have travelled.

The surmounting of steep gradients is only a question of engine power. With a sufficiently powerful engine it would be just as possible to run at 80 miles an hour up 1 in 100 as down 1 in 100. With another form of obstruction, however—sharp curves—it is in practice always necessary to slow down from motives of safety. Theoretically, it is possible to lay the line with the outside rail so much higher than the inside rail as to balance the tendency of the train to topple over, but, when a curve is at all sharp, the necessary tilt is so great as to be actually unattainable, and there is nothing for it but to slacken speed. Fortunately, most of the great main lines in Great Britain have been built without very many sharp curves. Great Western trains can run all the way from Paddington to Bath before encountering any curve where caution is necessary, and there are a good many stretches of 50 miles or more in all parts of the country, which are equally free from curves. But, though British main lines probably suffer less from curves than those of any other country, and where the lines, or at any rate the main lines, pass through open country, sharp curves have generally been avoided, there are all too many places, where the expense or the difficulty of getting land in or near towns, has made it necessary to introduce them. Consider the main line of the Great Eastern. The first biggish town after leaving London is Chelmsford, which is on a sharp curve ; the next is Colchester, also on a sharp curve ; the next Ipswich, on a sharp curve, and the worst curve of all is where, just outside Norwich, the line turns off towards Cromer. It is, of course, accurately known what are the safe speeds over curves of varying degrees of sharpness, and the limit prescribed always gives an enormous margin of safety—in one way too great a margin ; for the drivers, knowing that the margin is very great, may be tempted not to observe the limit, more particularly if, as is generally the case, there is no speed indicator on the engine, and no method of ascertaining afterwards what the speed really was, unless the train has been specially timed by some one with a stop-watch. Some years ago there existed on one of our most frequented main lines a curve, some distance before which there was the usual notice board announcing in large letters that the speed limit was 20 miles an hour. I once sat for three hours, timing the speed of the trains, as they rounded this curve. The fastest train took it at 48 miles an hour, and the slowest at 28 miles an hour. On another occasion I was on the engine of one of the principal expresses, and we ran a distance of just upon 2 miles, with this curve in the middle of it, in 2 mins. 9 secs. The curve in question now exists no more in its primitive sharpness—it has since been reconstructed—but when one thinks of the awful accidents which have taken place owing to the proper speeds having been exceeded on curves, it is felt that no precaution can be too elaborate to ensure that, where speed limits are prescribed, they shall also be respected. In saying this, I am by no means condemning high speeds on suitable parts of the line (*i.e.* everywhere, except those places where curves, or other obstructions—swing-bridges, for instance—exist, which make high speeds dangerous). On the contrary, it is certain that some absolutely reliable method of ensuring a suitable reduction of speed on sharp curves would remove the last lingering objection to really high speeds everywhere else. Who shall say how many centuries of unnecessary sitting in railway carriages the units forming the travelling public have collectively endured, owing to the fact that, one night in July, 1896, the precautions against excessive speed on curves taken by the North Western were insufficient to prevent the drivers of the two engines hauling the 8 p.m. Scotch express, from running their train off the line just north of Preston station? The summer before that unlucky accident took place there had been some real attempt on the part both of the East Coast and West Coast companies, in the race to Aberdeen to show how much, in the way of speed, their various engines could achieve, and these achievements were really remarkable, and opened up possibilities before unrealised, if not undreamt of.* The autumn of that year brought the

* The best runs on the West Coast were those of a 2–4–0 North Western engine, from Crewe to Carlisle, at a little over 67 miles an hour, and of a 4–4–0 Caledonian engine, from Perth to Aberdeen, at something under 67 miles an hour—each with a train of about 70 tons. On the East Coast, with a train of about 100 tons, a Great Northern 8 ft. single ran from Grantham to York at over 65 miles an hour, and a North Eastern 4–4–0 engine from Newcastle to Edinburgh at about 66 miles an hour. A North British 4–4–0 engine performed the very difficult run from Edinburgh to Dundee, with about 90 tons, at 60 miles an hour. The best West Coast run for the entire distance (540 miles) was 8 hours 32 minutes. The best East Coast run was 8 hours 40 minutes for 523½ miles. An examination of the details of the West Coast run shows pretty conclusively that the time for the whole distance could have been reduced to less than 8¼ hours. The road from Euston to Crewe is so much easier than that from Crewe to Carlisle that there can hardly be any doubt that an engine of the same type as that used between Crewe and Carlisle, and driven as hard, could have run the 158 miles at an average start-to-stop speed of 70 miles an hour. This would have involved a saving of 13 minutes on the time actually taken from Euston to Crewe. Then, on the Caledonian, the section from Carlisle to Perth, which, on this occasion only, was run without a stop, took practically as long as it had taken the night before, when a stop was made at Stirling, and there was an extra carriage on the train. Possibly the elimination of the Stirling stop was as broad as it was long, for it seems likely (though I do not know this) that the driver was hampered by the fear of not having water enough to complete the run, and so could not give the engine all the steam she would take. If my surmise is correct, and if a stop for water had been made (preferably at Symington, or Carstairs, instead of Stirling) so that the engine could have been run as hard as she would go the whole

11.50 p.m. from Euston, timed to reach Glasgow (401½ miles) in 8 hours,* and stopping only at Crewe, Carlisle, and Eglinton Street, a great improvement on any train to Glasgow that had existed up to then. The winter passed by, and, when the time-tables for July, 1896, came out, it appeared that, among other greatly improved trains on both East and West Coast routes, the West Coast companies had so timed the 8 p.m. from Euston that, in point of speed over hilly country, it was by far the most remarkable regular train, that had, up to then, been seen anywhere. It did not begin very fast, but, from the time it left Wigan to the time it stopped at Perth, it was to perform each of the three exceptionally hilly stages, Wigan-Carlisle, Carlisle-Stirling, and Stirling-Perth, at over 56 miles an hour start-to-stop, while, for the next —rather easier—stage to Forfar, the start-to-stop speed was over 60 miles an hour—32½ miles in 32 minutes. And, good as these speeds were on paper, it is certain that the intention was that performance should be better than promise, and it really looked as though the East and West Coast companies had grasped the idea that it was desirable radically to accelerate their best trains. But then occurred the Preston accident; for that part of its journey performed on the North Western, the 8 p.m. was re-timed, the remarkable run

way, the reduction in the gross load by about 15 per cent., as compared with the previous night, should have allowed a reduction of about 5 per cent. in the time taken, or, in other words, a gain of about 7 minutes. The East Coast, too, in spite of its heavier load, could undoubtedly have run faster than it did, at any rate south of Edinburgh, though in this case it does not happen to be so easy to indicate what might have been expected.

* Now slowed to 8¼ hours, except during the summer.

from Wigan to Carlisle ceased, and it was evident that the new-born energy, which had promised such great things, had received its death-blow. The Caledonian, it is true, which had just brought out the "Dunalastairs," retained its timings unchanged during that summer and autumn, and in practice often improved upon them. Indeed, the work of the "Dunalastairs" with this train—work which has already been referred to—was so remarkable that they at once made a name for themselves more celebrated than perhaps any other class of British engine has ever done. But, though the "Dunalastairs" achieved fame, their brilliant work was but a flash in the pan. The forces opposed to enterprise seized their opportunity and triumphed. An agreement limiting the speed of the Scotch expresses was shortly reached between the rival routes; by December 1, 1896, the new fast trains had been slowed down, and, from that day to this, the services between London and Scotland have never risen above mediocrity.

It is hardly possible to exaggerate the disastrous effect, which the slowing down of these trains had upon the development of the passenger service in Great Britain. The mere fact that it involved the permanent deterioration of the Anglo-Scottish services is bad enough, but, when it is remembered that the question of a great general acceleration of express trains had been forced to the front by recent events, and that, if the Anglo-Scottish lines had retained their accelerations, other railways could hardly have failed to follow suit, it is evident that a very heavy blow was dealt to the cause of progress by the withdrawal of the stimulating example of the most prominent railways in the Kingdom under circumstances which to some extent suggested panic.

From about this time, indeed, British express speeds, which up to then had easily been the best in Europe, were for some years completely put into the shade by those of the best French trains. The Nord led the way with whole series of very remarkable accelerations, and was followed shortly, on a smaller scale, by the Paris-Orleans and Midi, and subsequently, at a more or less respectful distance, by the other lines. The result was that the general level of the speed of the best French expresses became markedly superior to that of the best British expresses. As far as the Midi was concerned, the accelerated service did not last very long. About a year after the accelerations had been put into force, a very serious accident occurred in which the Sud-Express left the rails, when travelling at a speed of approximately 75 miles an hour. There does not seem to have been any particular reason for attributing the accident to the speed at which the train was running, as there was no curve to cause it, and the train had passed the same spot at about the same speed every day, or nearly every day, it had run. Indeed, the cause of the accident was so wrapped in mystery that many people thought it must have been due to the action of criminals, who desired to wreck the train in the hope of securing some booty in the subsequent confusion. The Midi, nevertheless, made haste to abandon its accelerations. The accident, however, failed to alarm any of the other French railways, and, till at least the year 1902, the best French runs remained immeasurably superior to the best British runs. From that time the British lines began to make up a certain amount of leeway, and, although Great Britain is far from having regained her ancient superiority, and further still from possessing a train service as rapid as is desirable, there is not at the present time much to choose in point of booked speed between the two countries, though, owing to the much more satisfactory way in which the making up of lost time is taken in hand in France, the work of the French locomotives is probably superior, on the whole, to that of the British locomotives.

It is from every point of view most desirable to take every precaution to avoid the recurrence of such an accident as that which took place at Preston. It would not cost more than a few pounds to put down, at the beginning and end of every sharp curve, clocks which would automatically record the hour, minute, and second, at which every train passed these two points, thereby giving a complete record of the speed. (In certain cases, indeed, recording arrangements of this kind already exist.) In this way it would be easy to ensure that no driver, who exceeded the speed limit, should escape detection, and, without in any way reflecting upon the caution and conscientiousness of engine-drivers, we may assume that they share in the failings of ordinary mankind, and would be far less likely to commit transgressions, which would undoubtedly be detected, than transgressions, which would almost certainly not be found out, as is the case where no record is taken; and, considering the very great importance of ensuring a sufficient reduction of speed on certain curves, it would certainly be worth while to spend a little money towards this end.

Though, as already remarked, the present policy of the railways does not appear to hold out any promise, it is, nevertheless, a fact that, if the history of the last quarter of a century is any guide, the time must be at hand for some fresh striking accelerations and high speed performances in Great Britain. In 1888 took place the race to Edinburgh, in 1895 the race to Aberdeen, followed by the remarkable, but abortive, accelerations of 1896, and round about the year 1904 there was a renewed outburst of energy, comprising some fresh records on the Western lines, and a very large number of accelerations in many different directions. These phenomena have thus occurred at intervals of approximately eight years, and another is by now overdue. The promise of the previous displays having, in every case, been followed by a more or less disappointing relapse, succeeded by a long period of comparative stagnation, it is to be hoped that next time a decided step forward is taken, the permanent benefit secured by the travelling public will be greater.

The whole subject of speed is one which appears to hurl railway managers into a torrent of conflicting emotions. It is patent that practically every railway attaches enormous importance to an extremely small advantage in speed over any rival line. The railway, which has once established its position as the possessor of the better route between two large centres, always clings with grim determination to its advantage in point of the quickest time of the quickest train, which is generally fixed at so many minutes less than the best time of its rival; and the rival, though respecting the time advantage agreed upon, is never willing to concede anything more than the minimum number of minutes, unless he is bought off by compensating advantages in some other directions. If any changes are made in the times of the fastest trains, both lines introduce the changes at the same time, and the relative positions of the two always remain very nearly the same. In late years this intense appreciation, on the part of the railways, of the value of speed, though it exists as strongly as ever, has in a good many cases been obscured by the introduction of pooling arrangements between lines, which used to be rivals, but can now no longer be considered as such. The only adequate explanation of the attitude towards one another, which rival lines take up in the matter of speed, is that railway travellers are believed to care so much for speed that they will flock to the faster line, even though the difference in time is very small. The North Western, in the days before it made its recent agreement with the Midland, always considered that it was entitled to an advantage of five minutes over that railway to Manchester, and the Midland allowed this contention. Some years ago, therefore, when the Manchester trains were quickened, and the best North Western time became $3\frac{3}{4}$ hours, the Midland was fain to rest content with 3 hours 50 minutes, and, when, a few years later, the North Western time was reduced to $3\frac{1}{2}$ hours, the Midland was still 5 minutes behind with 3 hours 35 minutes. As the North Western were so careful to insist upon this tiny advantage, it is clear that it must have had reasons for supposing that the travelling public were enormously attracted by speed. This being so, it would appear to be advisable for both lines to offer their customers the greatest possible measure of the speed, which they prize so highly ; and as certainly the North Western, and probably the

Midland could, without any particular difficulty, reach Manchester in 3 hours, there is considerable scope for attracting increased traffic, and swelling receipts by this means. But not so. Side by side with his desire to be ever so little in front of his rival, there resides in the railway manager's breast a passion of like intensity, which causes him with all his might to resist accelerations. We must suppose that the reason for this attitude is the belief that accelerations would not pay. It is open to the gravest doubt whether there is any foundation for this belief. It is universally acknowledged that, when the quality of any commodity is improved, while the price remains the same, the demand for it increases. There is, therefore, excellent reason for supposing that, if the railways improve their service (which is the commodity they sell) the demand will increase (*i.e.* more people will travel). If, then, by inducing people to travel, who would otherwise have remained at home, a railway can earn more in extra fares than it spends in securing the extra speed, it will profit by the transaction. It is worth while examining this question rather closely. As to the extra expense involved by accelerating, let us say, the 6.5 p.m. from Euston to reach Manchester at 9.5 instead of at 9.35, as it now does: First, more power will be wanted—let us say 50 per cent. more. To secure this, it will be necessary either to work the existing engine harder than is now done, or to employ a bigger engine. Let us choose the latter alternative. The existing engine costs, say £3000. The new one will cost £4500, and her upkeep will, each year, cost £300 instead of £200. An engine will last about 25 years, so the average annual expenditure on the bigger engine will be £480, as against £320 on the smaller, a difference of £160, to which must be added £75 for interest and sinking fund at 5 per cent. on the £1500 increased first cost of the engine, making £235 in all. 40,000 miles is by no means an unusual distance for an engine to run in a year, and on this basis the extra cost per mile of the big engine over the small one is less than $1\frac{1}{2}d.$ Next, the big engine will burn 50 per cent. more coal a minute than the small one, but only 33 per cent. more a mile—say 60 lbs. a mile instead of 45 lbs., which will work out at a difference of about $\frac{3}{4}d.$ a mile. The extra wear and tear of the tender and carriages will amount to very little, and, even if it were necessary to raise the wages of the driver and fireman to a small extent, it is difficult to see how the whole extra cost, so far as the train is concerned, could exceed $2\frac{1}{2}d.$ a mile.

There remains the extra wear and tear of the permanent way. It is much more difficult to give any estimate of what this is likely to amount to. The average expenditure on the upkeep of the permanent way all over Great Britain appears to be not more than 3*d.* per train mile. Whether or no express trains damage the road more than other traffic, it is very difficult to decide. The greater speed of the train would, indeed, appear to engender greater destructive forces. But so long as these forces are not great enough actually to break, or strain beyond its elastic limit, any part of the permanent way—and, with a really strong, well-kept road, they certainly would not be great enough—it is not easy to see where the extra wear and tear comes in. Then, with really good rolling stock, on a really good road, there is no doubt that the smoothness of motion at high speeds is remarkable, and, the higher the speed, the smoother the motion becomes. A gentleman, who travelled in one of the high-speed electric cars, used in the speed experiments on the Berlin-Zossen railway, told me that at 130 miles an hour the car hummed along without a jolt or a lurch. On the other hand, it is a common experience to find railway vehicles more unsteady at 55 miles an hour than at any other speed—higher or lower. One reason for the greater smoothness of motion at high speeds appears to be the decreased shock as the wheels pass over the rail-joints, which are the weakest part of the permanent way. The higher the speed, the greater, theoretically, must become the tendency of the wheels to fly the joints, and this seems to be what actually occurs in practice.

It is obvious that the elucidation of the effect, which the speed has upon the permanent way, would be greatly assisted, if it were possible to obtain figures showing the relative cost of maintenance of the uphill and downhill lines upon banks steep enough to make the speed of the trains ascending the banks much less than the speed of descending trains. Unfortunately, there do not appear to be any figures of the kind obtainable. I am, however, informed by a gentleman, who is in the best position to judge, that he is under the impression that, if figures were available, it would be found, generally speaking, that the cost of maintenance of each line was the same.

If the question of the permanent way were really a serious one, it would be quite easy greatly to reduce the strain to which it is now subjected. Far the greatest strain which it supports, is that put upon it by the driving and coupled wheels of the engine, which sometimes have as much as 20 tons upon each axle, while the engine is standing still. When an ordinary 2-cylinder engine is moving, this weight increases and decreases once in each revolution of the wheels, owing to the action of the weights used to balance the reciprocating parts of the machinery, and, at high speeds, the increase amounts to several tons. If, instead of a 2-cylinder engine, a 4-cylinder engine of suitable construction is used, this action is enormously reduced, and could be got rid of altogether. It is, also, unnecessary to put more than 16 tons or so, each, upon the driving and coupled axles; the engine then will not be quite such a rapid starter as one with more weight upon these axles, or quite so well able to take heavy loads up very steep inclines, but otherwise her efficiency will be no whit diminished.

In view of all this, it is extremely probable that any feasible acceleration would involve very little extra expense of account of the maintenance of the permanent way. If, however, the actual facts are the most unfavourable that could, with any show of reason, be supposed to exist, it must still be well within the mark to assume that the existing Manchester express occasions so much as three times the average wear and tear to the permanent way, and that for still higher speeds the wear and tear will continue to increase as the square of the speed. This would mean that, while the existing train costs 9*d.* a mile, a train performing the distance in 3 hours would cost 1*s.*—*i.e.* 3*d.* a mile more. Adding to this the 2½*d.* a mile already arrived at as the extra expense connected with the train proper, the total increase of expenditure involved in running a train to Manchester from Euston in 3 hours, as against the present $3\frac{1}{2}$ hours, would be, on the most unfavourable assumption $5\frac{1}{2}d.$ a mile, and in reality almost certainly much less. That is to say that the acceleration would, in any case, bring the railway a clear profit, if six more third-class passengers could thereby be induced to travel. There are certain other minor points, connected with the subject, which need not be touched on, but enough has been said to suggest that radical accelerations offer an extremely good prospect of profit to any railway that will try them. That railway managers are, as a rule, intensely unwilling to accelerate their trains is undoubtedly true, but, when the facts are closely considered, it seems doubtful whether they do not give too much consideration to the arguments against increased speed, and too little to those in favour of it. In course of time, perhaps, some one in authority will realise that it is advantageous for all concerned to get people over the ground as rapidly as possible, and not, as at present, at speeds, which the railway companies affectionately regard as "quite fast enough."

Having discussed the question of the probable cost of the acceleration of a particular train, it may be worth while to go further, and consider how great a speed might reasonably be achieved at the present time, with a train big enough to contain an adequately paying complement of passengers. Let us take the case of a train, weighing 200 tons (without engine and tender), running from Euston to Edinburgh with two stops—at Crewe and Carlisle—and drawn by engines capable of developing 1500 horse-power continuously. The weight of the engine may be put at 75 tons and that of the tender (fitted with a water pick-up arrangement) at

35 tons when full, and 25 at the end of the run. The weight of the complete train will thus average a little over 300 tons. The power required to move a given train at a given speed varies to some extent according to circumstances—the state of the permanent way, the direction and force of the wind, etc.—but, under ordinarily favourable conditions, such as obtain six days a week, an engine exerting 1500 horse-power on a level line should maintain a speed of not less than 78 miles an hour, with a gross load of just over 300 tons. (This corresponds to a resistance of 24 lbs. per ton of train at this speed.) This average speed would be maintained on a perfectly level road, but the undulating character of all actually existing lines would reduce the average speed to a greater or less extent, according to the severity or otherwise, of the undulations. Between Euston and Crewe, the undulations are very gentle and a reduction of 2 miles an hour would be a sufficient allowance, while between Crewe and Carlisle, and Carlisle and Edinburgh the severity of the gradients would probably cause a diminution of 5 miles an hour. Between Euston and Crewe, therefore, the average speed, so long as the engine was working at her full power would be 76 miles an hour, and, for the other two lengths, 73 miles an hour. There are, also, to be taken into account the delays due to starting and stopping, and those due to the necessity of slackening speed at certain curves and junctions—say 4 minutes on each section for starting and stopping, and 3 minutes each, passing Rugby, Stafford, and Strawfrank Junction near Carstairs, and 5 minutes passing Preston, at each of which points a serious reduction of speed is necessary. This would leave the running time, for the

158 miles between Euston and Crewe, 2 hours 15 minutes; for the $141\frac{1}{4}$ miles between Crewe and Carlisle, 2 hours and 5 minutes; and for the $100\frac{3}{4}$ miles between Carlisle and Edinburgh, 1 hour 30 minutes. So, with 5 minutes' stops at Crewe and Carlisle, the total time from Euston to Edinburgh would be 6 hours. If any one should really doubt the ability of a properly designed engine, weighing 75 tons, to go on developing 1500 horse-power for the necessary periods of time, I can only ask him to go over to France, and carefully observe the work of some of the express engines on the Nord. I have, on several occasions, seen the 4–4-2 express engines of this line, which weigh only 63 to 65 tons, go on for 10 or 12 miles together, doing work which, calculated according to the generally accepted tables, amounted to 1500 horse-power,* and this without the boilers running short of steam or water, so that there was no apparent reason why they should not, if necessary, continue indefinitely to work as hard as this. On one occasion in particular one of these engines was working a train which, though not extraordinarily heavy, ran very stiffly, and for 20 minutes on end she ran, with the regulator wide open and with a longer cut-off, at considerably higher speeds, than her sister-engines had done on the occasions referred to, so that it looks as though a continuous effort of 1500 horse-power were well within the capabilities of these machines. (The particulars of this last-mentioned performance were as follows: average speed, 69 miles an hour; steam pressure near the blowing-off point of 227 lbs. a square inch; dimensions of high-pressure

* This, moreover, was before these engines were fitted with superheaters, as has now been done.

cylinders, $13\frac{3}{8}$ inches by $25\frac{1}{4}$ inches ; cut-off in the high-pressure cylinders, 55 per cent. ; diameter of driving-wheels, 6 feet 8 inches.)

The Nord, moreover, now possesses engines which are a great advance upon those whose work has just been described. I have lately had some experiences on that railway, which throw a good deal of light upon the question of the capabilities of big modern locomotives. Not very long ago 20 new express engines were acquired of the 4–6–2, 4-cylinder compound type, fitted with Schmidt superheaters. The boiler barrel is about 5 ft. 6 ins. in diameter ; the grate, which is of the ordinary narrow sort, has an area of $34\frac{1}{2}$ square feet ; and the safety valves blow off at 227 lbs. per square inch. The weight of the engines in working order is a little over 84 tons—not very much more than that of a good many of the biggest British express engines, and much less than the Great Western's " The Great Bear." The tenders, with the full load of coal and water, weigh 47 tons.

I had a number of journeys with these engines on the main line between Paris and Calais, and up all the principal inclines, on the occasions in question, they were invariably worked at approximately their full power, with the result that I witnessed some remarkable performances.

Between Paris and Amiens the two principal inclines are those which lead up to the Survilliers and Gannes summits, which are situated, respectively, between kilometre * posts 27 and 28, and near post 86 from Paris.

The Survilliers bank begins about post 7. It ascends almost all the way at 1 in 200, but there are

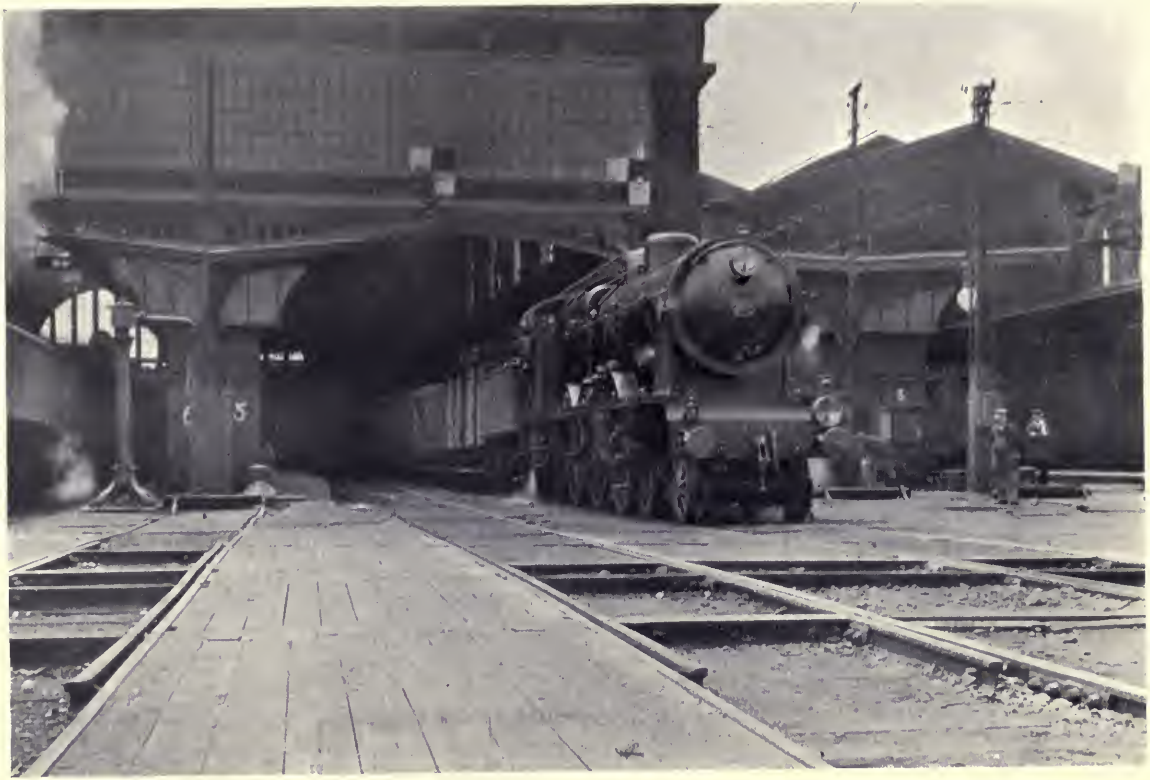
* A kilometre is about 1094 yards, or very nearly $\frac{5}{8}$ths of a mile.

short pieces of easier gradient, which bring down the average steepness to about 1 in 230. It must also be remembered that these particulars apply to the old line, now used for suburban trains. A few years ago a new double line was built for the express trains. This line is very slightly longer than the old line because it curves to avoid the station yards, but the positions of the kilometre posts have not been changed; the introduction of curves, no doubt, slightly increases the resistance of the trains.

The Gannes bank really begins at about kilometre 48, before the station of Creil; but much the hardest part is comprised in the last 20 kilometres from post 66. Hence, for two-thirds of the way to the summit the gradients average about 1 in 265. The remainder averages about 1 in 310, which is the actual rate of ascent for the last 2 or 3 kilometres.

My first run was with engine 3.1156, working the mid-day train, which weighed 292 English tons (exclusive of engine and tender*). The engine accelerated very rapidly from the start, and, helped by the falling gradients, which exist for the first mile or two, reached 60 miles an hour before passing kilometre 4—say about 2¼ miles from the start. A slight slack followed, where some facing points had to be passed over, but kilometre 7 was passed 5 minutes 56 seconds from the start. Here, with the regulator wide open, and steam cut off in the high- and low-pressure cylinders, at 55 and 65 per cent., respectively, we began to climb the bank, which extends for more than 12 miles to the Survilliers summit. As we proceeded, the cut-off was gradually

* The weights of the trains are invariably given exclusive of engine and tender, unless otherwise stated.



ENGINE 3,1156 ABOUT TO LEAVE THE GARE DU NORD ON THE RUN DESCRIBED IN THE TEXT.

increased to 62 per cent. in the high-pressure cylinders, with the result that the speed, instead of falling as we ascended the bank, increased till the 25th kilometre was run at $67\frac{3}{4}$ miles an hour, and for the last kilometre wholly uphill (the 27th) it was $66\frac{1}{2}$ miles an hour. The 20 kilometres from post 7 had occupied 11 minutes $37\frac{3}{5}$ seconds, which is equal to an average of 64·1 miles an hour.

The ascent of the last 20 kilometres of the bank to Gannes was scarcely inferior. We began it at about 64 miles an hour; again with the regulator wide open, the cut-off was gradually increased as we ascended the hill, and we finished up by running each of the last 3 kilometres at 69 miles an hour, while the average speed for the 20 was 65·8 miles an hour.

On both ascents the engine steamed well, the pressure being maintained at, or very near, the blowing-off point of 227 lbs. per square inch; the temperature of the superheated steam was about 645 degrees Fahrenheit; the pressure in the receiver rose to a maximum of about 56 lbs. per square inch, and the variable blast pipe was set to give an orifice equal to a circle something over $6\frac{1}{2}$ inches in diameter, except towards the ends of the periods of hard running, when the opening was yet further increased.

These were actually the best performances which I witnessed on these inclines, but I had four more runs up each of them with sufficiently interesting results. Up the Survilliers bank the 20 kilometres from post 7 were run, respectively, at 63·1, 62·5, 61·7 * and 63 miles an hour, and the speeds for the 27th kilometre

* In this case the brake of the tender had inadvertently been left slightly on.

were 65, 62·8, 61·4, and 63·5 miles an hour. Up the Gannes bank the 20 kilometres from post 66 were run, respectively, at 65·6 (in this case the speed is for the 19 kilometres from post 67), 63·7, 65·7 and 63·9 miles an hour; and the speeds for the 86th kilometre were 66·1, 65·4, 68·1 and 64·2 miles an hour. The weights of the trains were 291, 296, 285, and 287 tons.

Beyond Amiens the worst bank on the way to Calais is that leading up to Caffiers. It begins at about kilometre 268, and extends to a point some way beyond kilometre 277. The ascent is at 1 in 125 the whole way, except for about 400 yards near kilometre 270, where it is 1 in 400.

Up this bank I had two runs under the conditions already described. The first was on engine 3.1154, with a train weighing 296 tons. The bank was begun at a speed of about 70 miles an hour, and the 10 kilometres from post 268 were run in 6 minutes 35 seconds, which gives an average speed of $56\frac{1}{2}$ miles an hour. The speed for the last kilometre wholly on the gradient of 1 in 125 (276–277) was $53\frac{3}{4}$ miles an hour. The second run was with engine 3.1157 and 287 tons. The speed at the bottom of the incline was some 5 miles an hour higher than on the previous occasion, the 10 kilometres from post 268 occupied 6 minutes $9\frac{1}{5}$ seconds (over 60 miles an hour), and the 277th kilometre was run in $39\frac{3}{5}$ seconds (56·4 miles an hour). In both these cases, though the reversing gear was practically in full gear for both the high-pressure and low-pressure cylinders, the boiler pressure was maintained at the blowing-off point without difficulty. No steam was admitted direct to the low-pressure cylinders on these or any other occasions, while the engines were working hard.

Perhaps the most remarkable run of all was one from Amiens to Paris. On this occasion the engine was No. 3.1160, and the train weighed 321 tons. The principal banks to be ascended on this run are again those leading up to the Gannes and Survilliers summits, and they are fairly similar to those by which these summits are reached from the direction of Paris. The former begins about kilometre 120, and ascends nearly as far as kilometre 104, principally at 1 in 333; short lengths rising at 1 in 250 and little bits of level at intervals about balance one another, so for these 16 kilometres the gradient may be regarded as equivalent to 1 in 333 throughout. From about post 104 the line falls for a short distance at 1 in 250. Then from post 102 there are a further 8 kilometres averaging about 1 in 333 up. This is followed by about 2½ kilometres of level line, and then the final climb to post 87 is at 1 in 250 and 1 in 268.

The ascent to Survilliers consists of 20 kilometres from post 48 to post 28. It is at 1 in 200 throughout, except for three short pieces of easier gradient, which reduce the average ascent to about 1 in 220.

From about the bottom of the Gannes bank as far as kilometre 106, we kept up something over 61 miles an hour; soon after this, speed was reduced to pass over a bridge which was under repair, but then the pace steadily rose till, on the level piece before the final ascent, it reached 70 miles an hour, and, falling only very slowly indeed on the final stretch of 1 in 250 and 1 in 268, was still 69·4 miles an hour at the summit.

On the Survilliers bank we were very much hindered by an adverse signal, which obliged us to slow down to about 35 miles an hour at post 45. But from here we steadily gained speed, as we climbed the bank, till at the summit we were running at 64·2 miles an hour. Thus, with a train of a total weight of not less than 440 tons, within a space of about 10 miles, up 1 in 220, the speed had risen by nearly 30 miles an hour.

On another occasion No. 3.1170, working the same train, with a load heavier by one ton, was running at 63·9 miles an hour at the Gannes summit, and ascended the last 14 kilometres to the Survilliers summit at an almost unvarying speed of 62·1 miles an hour, which was exactly the speed at the summit itself. This engine was handicapped by the fact that she had been out at the shops for a long time and was in need of overhauling.

Downhill there was no opportunity for the engines to show their powers, as the speed limit of 120 kilometres (74·56 miles) an hour is always respected. Neither was it possible to do much on the level. Nevertheless, No. 3.1152, with a train of 360 tons, ran for a short distance along the level at 72·6 miles an hour.

A noteworthy point with these performances is that they were done under completely normal working conditions. No sort of special preparations were made before the engines came on to their trains, the fuel was not specially selected, and the engines were taken just as they came—no attempt was made to secure the better ones and avoid the worse—nor did the drivers ever know beforehand that their engines would be called upon to make special efforts. The weather was generally dry. There was quite the normal amount of wind—usually from the north or north-west.

If the usual formula for ascertaining resistances is applied, it is found that on at least half a dozen different occasions the horse-power must have reached, or exceeded, 2000.

Great Britain is probably the only country in Europe where the maximum speed of trains is not limited by law. Seventy-five miles an hour is generally the highest speed which any express on the Continent is allowed to attain. British expresses have in this way a certain advantage over their Continental rivals, though, under present conditions, the amount of time saved by any British express train by travelling at speeds higher than 75 miles an hour is remarkably small, for speeds greater than this are hardly ever attained, except for short distances, down comparatively steep inclines. All that can be said is that the downhill work of British engines is more interesting to the investigator than that of Continental engines, because there is always just a possibility of the British engines reaching really high speeds.

The North Western service to and from Birmingham is one of the cases in which the beneficial results of competition can be clearly traced up to a certain point; after that point the deadening grip of the agreement, by which further competition is to be avoided, can be observed only too plainly. During the years before the Great Western began to awake from its long sleep, the North Western, having then a much shorter line than the Great Western, had no difficulty in keeping the principal part of the Birmingham traffic for itself, with a rather inferior service of trains. When the Great Western service improved, the North Western was still careful to keep ahead, and improved its service till, in order presumably to consolidate its position, in view of the approaching opening of the Great Western's new line to Birmingham, shorter than its own, it reduced the time of all the best expresses to two hours in either direction; later, on the eve of the opening of the new Great Western line, it turned to account the line of the North London railway, to assist it in maintaining its position. The North Western has long had a controlling interest in the North London, but it has lately made its connection closer, and the North London now forms, to all intents and purposes, part of the North Western system. The North Western now makes use of the North London terminus at Broad Street, to run direct to that station a train from Birmingham, which thus deposits its passengers in the heart of the city.

Now that the new Great Western route is open, that line also runs its best trains to and from Birmingham in two hours. About the time of the opening of the new Great Western route, inspired paragraphs appeared in plenty in the newspapers, pointing out that the two lines had agreed neither to reduce their time under two hours, and suggesting that it was a splendid thing for everybody that what the railway officers like to call "wasteful competition" had been avoided. In what way the public benefits by the time remaining at two hours, instead of being reduced below that point, was not explained. The time has certainly arrived when the speed of the best trains between London and the nearest very large provincial town, served by the two largest railways in England, both of whom possess quite easy routes, should be well over 60 miles an hour. Dare one suggest to the officers of the North Western and Great Western Railways that the proper time for the expresses to take between London and Birmingham is 100 minutes?

In one respect British railways stand pre-eminent among those of all the world, and that is in the number of long runs which are performed by express trains without a stop. It is the widespread adoption of the Ramsbottom water troughs, from which the engine can pick up water while running, that has enabled British railways to accomplish this. The troughs can be laid down on any level piece of line 500 or 600 yards long, even if there is a gentle curve. They are some 18 inches wide, and are placed mid-way between the rails. Under the tender there is a scoop, which normally lies well clear of the sleepers, but which can be lowered, when necessary, by means of some pneumatic, or other arrangement, so that its mouth descends some inches below the level of the water in the troughs. On reaching a trough, the fireman lowers the scoop, and the water, impelled by the impetus of the train, rushes up the scoop, and thence up a vertical pipe (which is a continuation of the scoop), out of which it overflows into the tank of the tender. If the line were level at either end of the trough, the scoop must strike against it, if not raised out of harm's way. For this reason the line is arranged to fall slightly for some distance as the train reaches the trough, and to rise again to the same extent at the end, as it passes off it. The ballast, where troughs exist, is constantly being flooded, and must be laid and maintained in the most careful way.

To begin with a speciality of the North Western, the troughs were for many years used successfully by that line before their utility was recognised to any extent elsewhere. The North Western did not perform longer runs without a stop than other companies, and, though the troughs afforded certain conveniences for conducting the traffic, it was quite easy to get on without them, and they were generally neglected. One or two companies performed runs of over 120 miles without using troughs, and it does not seem to have occurred to any one that longer runs than this were desirable. Some striking object-lesson was necessary to impress upon people's minds the advantages of the water troughs, and this object-lesson was supplied in 1895, when the railway race to Aberdeen, between the East and West Coast routes, took place. During that race the North Western, with much lighter tenders than any of the other companies concerned, regularly took the West Coast train to Carlisle (299¼ miles), with only one stop, while in the remaining 240½ miles to Aberdeen, the Caledonian normally stopped (at least) twice, and the East Coast stopped five times in covering its 523½ miles. The average length of run was, therefore, for the North Western, about 150 miles; for the Caledonian, 80 miles; and for the East Coast companies, 87 miles. The Caledonian, it is true, on the last night of the race, managed to cover the 150¾ miles from Carlisle to Perth, without a stop, but the train was even lighter than usual, and the speed for this stage was a good deal lower than for any of the other stages of the journey, so that it looks as if water had to be economised. After the race to Aberdeen, one company after another adopted the troughs, and all the English companies, whose main lines are more than 100 miles long, except the South Western, now use them, though they are not so far employed in Scotland. Perhaps one of the reasons for the troughs not being laid down in Scotland is that, owing to the greater severity of the winter in the north, it is feared that they would comparatively often freeze, and so be rendered useless. This is not, of course, anything like a complete explanation, and a more powerful reason probably is that, owing to the hilly character of most of the Scottish main lines, it would be more difficult and expensive than usual to arrange for an adequate number of troughs in the places where they are wanted.

The most obvious use of the troughs is to enable long runs to be made, but they have a variety of other uses. One of the most economical steps that a railway can take is to supply the boilers of its engines with water which will not deposit hard and adhesive scale. As it does not matter much, to ten miles or so, where the troughs are situated, it is often possible to choose a spot where a natural supply of good water is to be had cheaply, and, even if good natural water is not available, a water-softening installation on a large and economical scale may be arranged to feed the troughs. The first cost, and the weights of the tenders also, can generally be made less on railways which use water troughs, and, owing to the elimination of stops, the line may perhaps be able to accommodate more trains in a given time.

The ordinary "simple" engine is a very compact and handy machine, but not particularly economical. Some half to two-thirds of the energy set free by the combustion of the fuel, passes into the boiler, which, all things considered, is not a bad result; but the proportion, which is utilised in the cylinders, of the energy stored up in the steam is quite small, and here there is great scope for securing increased economy. In simple engines it is difficult to make the steam expand to more than about three times its original volume, partly because the valve-gears generally used do not lend themselves to such an operation, and partly because a much greater expansion than this in a single cylinder involves so great a difference in the temperatures of the steam at the beginning and end of the stroke of the piston, that a great deal of heat is lost by the incoming steam having, during each stroke, to warm up the cylinder, which has been cooled by the relatively cold steam just escaped. When, therefore, it is desired to carry the expansion of the steam to great lengths, this is done by passing it through two successive cylinders, in each of which some expansion takes place, and the engine is called a compound. For a long time the North Western used a great many compound engines, while only a very few were found on other British lines. Compound engines did not by any means at once prove themselves superior to simple engines, and, even now, the only country, where the compound really reigns supreme, is France. What has stood in the way of the compound engine is the fact that she is necessarily more complicated than the simple engine, and if there is one thing, more than another, that a British locomotive superintendent hates, it is complication. For a long time, therefore, such British designers as, moved by the economy promised by the compounds, could prevail upon themselves to give the system a trial, spent all their ingenuity in endeavouring to turn out compound engines, which should contain the smallest possible number of parts, and be as much like ordinary engines as possible, instead of frankly recognising that compound engines are more complicated than 2-cylinder simple engines, and that the multiplication of parts must be faced. Dominated by the idea of simplicity at all costs, the Great Eastern, and afterwards the North Eastern, built 2-cylinder compounds. This, of course, involved the use of unusually heavy reciprocating parts, and of a high-pressure and a low-pressure cylinder of different sizes, which made an unsymmetrical engine; when, as in some engines of this type, the cylinders, which were inside the frames, had to be placed with their axes at different angles to the horizontal, while the valves were arranged outside the frames, the fresh complications introduced were worse than those avoided. The North Western built engines with two pairs of uncoupled driving wheels, the second pair driven by two small high-pressure outside cylinders, and the first pair by a very large low-pressure cylinder on the centre line of the engine. A peculiar form of valve gear fitted to the low-pressure cylinder, together with the absence of coupling rods, is reported to have had the effect of sometimes making the two pairs of driving wheels revolve in different directions at starting, while the great weight of the low-pressure piston, which moved in constantly varying relation to the high-pressure pistons, was not conducive to steadiness of motion. Later, the North Western began building 4-cylinder compounds, but here again, for the sake of simplicity, each group of two cylinders—one high-pressure and one low-pressure—was provided with one set of valve gear only, so that the cut-off in the low-pressure cylinders was very nearly the same as in the high-pressure cylinders. In compound engines (at least in the case of those working with saturated steam —when the steam is superheated, the matter seems to be somewhat different), unless the low-pressure cut-off is much later than the high-pressure cut-off, the engine gets choked, if the low-pressure are not enormously bigger than the high-pressure cylinders. In the North Western engines the low-pressure cylinders were only about twice as big as the high-pressure cylinders, and, in consequence, the steam was not used in the best manner. The first compound engines which were really successful were the French type. Here simplicity was thrown to the winds. Four cylinders were used—two high-pressure outside, and two low-pressure inside, the frames—driving separate axles, which were coupled together, so that the high-pressure and low-pressure pistons always moved in the same relation to each other, and each pair of cylinders had a separate set of reversing gear, so that the high-pressure and low-pressure cut-offs could be varied separately. Slightly less complicated 4-cylinder compound engines appear now to be working satisfactorily in various parts of the world, and the Midland has got good results from 3-cylinder compounds, which possess several great advantages over the 3-cylinder engines, which the North Western used to build, in that all the pistons are of approximately the same weight, and their relative positions are unalterably fixed. While there appears to be little doubt that properly designed compound engines are more economical than simple engines, the prejudice against the compounds is, in Great Britain at least, still very strong, so much so that, even when, as is the case in certain very powerful engines recently built, four cylinders are used, and not very much extra complication would ensue from making two of them high-pressure and two low-pressure, all four are nevertheless made high-pressure cylinders.

The North Western, having continued for more than twenty years to build compound engines—for both passenger and goods trains—with three or four cylinders, appears to have been forced to the conclusion that these engines did not do sufficiently well to make up for their greater complication, and some nine or ten years ago the company entirely ceased building compounds, and with little delay scrapped or converted into simple engines the greater number of the compounds which it possessed. Indeed, there was something approaching a complete and sudden disappearance of the compounds. At this time the practice of using two engines on one express train had become extremely common, and it was apparent that the North Western must follow the example already set by several other railways, and introduce express engines of greater power than those which had so far been employed. So the North Western brought out two new types of express engine, in which the simplicity, which generally characterises British designs, was extremely pronounced. One of these types was a new 4–4–0 design, which, weighing as it does, close upon 60 tons (without the tender), approaches the limit of weight permissible in such engines. The other was a six-coupled (4–6–0) engine, as much like the four-coupled engine as possible, but with driving wheels 6 ft. 3 ins. in diameter, instead of 6 ft. 9 ins., and other modifications necessitated by the general design. The principal drawback of the six-coupled engine appears to be the shallow fire-box—a defect shared, to a greater or less extent, by all six-coupled express engines without an uncoupled trailing axle—which must make it impossible to force the fire to the same extent as can be done in the exceptionally deep fire-box of the four-coupled engine.

A notable feature in North Western locomotive practice is the great extent to which the Joy valve gear is used. In this gear the valve is driven through an ingenious, and remarkably simple, system of levers, one of which is attached to the middle of, and takes its motion from, the connecting rod. Mechanical purists may object that it is not a good thing to put a bending strain upon the connecting rod, which has quite enough to do anyhow, and a breakage of which may entail such disastrous consequences; or they may maintain that, when this gear is used, the movements of the driving-axle springs cause too great disturbances in the action of the valve. But the gear has been in use too long, and worked too well, for objections of this kind to have serious weight.

The good results to be hoped for from each railway's employing rolling stock and appliances of its own type have been pointed out in a previous chapter, but for the fullest advantage to be got out of this state of affairs it is desirable that frequent opportunities should be taken of carrying out comparative trials between the different designs in use on the different lines. Little of this has ever been done. The engineers of the different railways, no doubt, often meet and compare notes, and inspect each other's productions, but actual comparative trials seldom take place. The North Western, however, recently broke with this tradition in a very marked way, and arranged exchanges of engines between itself and a number of other railways. The results of these trials have not been made public; indeed, it is undesirable that they should be, because, in cases of the kind, so many circumstances might affect the results obtained as to make figures extremely misleading to the casual reader. But nothing is so likely to suggest to an engineer desirable modifications of his own designs as the close observation of the way in which other people's designs fulfil the requirements of his own case. The North Western has lately brought out a 4-cylinder simple express engine, which looks as though the experience gained with a 4-cylinder Great Western engine had borne fruit.

The effect of the existence of several routes from London to almost all other big towns is to give a very large number of connections between them daily. Many of the principal routes of the North Western have enough advantage in point of time over the routes of other companies to make the North Western route the one which is normally taken by the majority of passengers, and the number of trains provided by this line alone is generally somewhat greater than the number to be found on the most frequented long-distance, or fairly long-distance, routes on the Continent. There can hardly be two towns in the world, between which one would expect to find a greater number of travellers, than Berlin and Hamburg (178¼ miles). The Prussian State Railways provide 12 trains a day from Berlin to Hamburg. The North Western, according to the A.B.C. Railway Guide, runs 15 trains from London to Manchester (183½ miles by the shortest way) and 13 to Liverpool (192¼ miles); but, if all the trains on all the different routes between London and these two places are counted up, the Manchester total reaches 59, and Liverpool total 52. To Bristol (117½ miles), on the other hand, where the only direct route is by the Great Western, there are 16 trains a day. The difference between the treatment received by these various places is probably much more apparent than real. So long as there is an express train every two hours or so, it is difficult to see what more can be wanted, and any great increase beyond this in the number of connections between any two places can hardly be due to a public demand; rather is it due to the necessity of providing for the service of the intermediate stations and junctions on the various routes. It is, indeed, a well-established fact that, since the closer agreements between the various companies have come into force, the reduction in the train service, which has been found possible, is extremely small, much smaller than was generally anticipated would be the case. Moreover, the railways, having found that close agreements with one another did not enable them, even experimentally, to venture upon any great reductions in their services, were obliged at the time of the coal strike of 1912 to study the question from another point of view. At this time all the railways, except the Great Eastern, which had thoughtfully laid down very large reserves of coal, were compelled greatly to reduce their services, and to maintain them for many weeks in a reduced state. But even the experience gathered during this prolonged period apparently failed to convince the railway companies that anything more was desirable than perhaps a few moderate reductions in their services. All this is a very considerable justification for the railway policy which was pursued in early times—that of allowing railways to be built anywhere, where a local demand existed—and, although it can hardly be doubted that, if railways were to be laid out afresh, a smaller mileage than now exists would be made to suffice, it is likely enough that the rather ample facilities, which the existing system affords, have caused a much greater traffic to be created than a system laid out in the most economic manner could have done. Not only is there great difficulty in reducing the train service, but the number of stations which can be closed is remarkably small, and it seems certain that very few existing facilities of any kind can profitably be curtailed. This, of course, means that very little of the labour engaged in the conduct of the traffic can be dispensed with as a result of the agreements which have been made. Such economies in labour as may prove feasible are likely to be chiefly in clerk labour. A considerable reduction in the number of clerks engaged by the railway companies (and, eventually, perhaps, by the Clearing House) may prove to be possible, as it is obvious that, when once an agreement between two or more railways has been got into good working order, there are likely to be far fewer points of friction between them, which might give rise to discussion and correspondence, than there would be between more or less jealous rivals, and various simplifications and economies in administration may be possible also.

The North Western was up to a short time ago so well satisfied with its important long-distance traffic out of London that it did little to develop such suburban traffic as it possessed. Four or five years ago, however, it came to the conclusion that the time had arrived for a change of policy, and it is gradually putting in hand a scheme for opening up the suburban district, through which its main line runs. The original intention was that a new line should start from a deep level station underneath Euston, and run underground for several miles, where it is practically impossible to secure land above ground for widening purposes, and then, when it emerged from the town, would continue on the surface. The above-ground part of this scheme was begun some time ago, but the construction of the elaborate and costly underground line, and the deep level station, was put off. On consideration, Euston did not appear to be the place at which the great body of suburban passengers would find it most convenient to arrive in London, and it seemed as though the considerable expense, which would be involved by the construction of the underground line, might (partly at least) be saved, while greater conveniences might at the same time be offered to the public, if arrangements could be made for conveying passengers to a number of different points. The outcome of this was a completely new scheme, which is to give passengers living along the North Western line between London and Watford unique facilities for reaching practically every part of the Metropolis. From the suburban stations new electrical services are to be introduced to Broad Street, along the North London line, which has meanwhile passed under the control of the North Western company, to Euston itself along the existing surface lines, some of which are to be arranged for electric traction, and to various other points in different directions, along existing lines which are also to be electrified, while a direct connection will be made between the main line at Queen's Park and an extension of the present Baker Street and Waterloo Tube, which it is proposed should be built with capital provided by the North Western.

In one way most of the London termini are inconveniently placed, as in nearly every case, except that of the railways to the west, the line rises out of London, and there is very often a steep ascent almost from the terminus itself. The North Western, which is blessed with very easy gradients over the greater part of its principal main lines, suffers as severely in this way as any of the railways running out of London, for almost immediately after leaving Euston there is an ascent of 1 in 70, or so, for some distance. This must always be something of a drawback, but if there is a little piece of exceptionally steep gradient anywhere, it is perhaps more convenient to have it close to the starting-point, as, if it is necessary to help the trains up the bank with an engine pushing behind, the delay involved by stopping in mid-career for a pushing engine to come on, is absent. Once clear of this ascent, the North Western main line gives very easy running as far as Crewe. There are one or two curves where a certain amount of caution is necessary, but otherwise the running conditions are extremely favourable, and the branches to Birmingham, Liverpool and Manchester present few difficulties. On the main line north of Crewe there are some miles of more difficult gradients before Preston, but it is only for the last 60 miles to Carlisle that the gradients are continuously severe. In the 31 miles between Carnforth and Shap summit the line rises some 900 ft., the steepest piece being the last 4½ miles from just beyond Tebay, which is 1 in 75. For a great many years there has been talk of constructing a tunnel, by which the trains would avoid the climb to Shap summit, but nothing has so far come of it, and the engines will probably continue to pant over this mountain road for a very long time to come.

Scotland is a country where the distribution of the population would, in any case, make it very difficult sharply to divide the spheres of the different railways. There is a rather narrow industrial zone, stretching roughly across the middle, north-east to south-west, where the population is very thick, and hardly anywhere else any traffic of much value except the tourist traffic.

In many ways the Caledonian Railway lies in an advantageous position. Its main line from Carlisle to the north keeps very much to the centre of Scotland, and so makes it easy to serve the places on either side by means of branch lines, while the main line itself keeps quite clear of Edinburgh on the one hand and Glasgow on the other. From Carlisle to Edinburgh and Glasgow the Caledonian follows the same line for nearly three-quarters of the way, and yet the Caledonian route to both of these places is a distinctly better one than the direct North British line to Edinburgh, or the direct Glasgow and South Western line to Glasgow. But, if its central position gives the Caledonian numerous advantages, this position also has its drawbacks in that, except for a few outlying districts, the Caledonian has practically no part of Scotland to itself. Protected on the north and south by the estuaries of the Tay and Forth, the North British has contrived to secure for itself the whole of the county of Fife, while a large part of Ayrshire is a Glasgow and South Western monopoly. But the Caledonian cannot claim as its own preserve any considerable part of the central industrial zone. In the country lying to the east of Glasgow hardly a single place exists which is not quite close to some line or other of both Caledonian and North British, and there can be few districts anywhere so closely intersected throughout by the lines of two independent companies. Further west to the south of the Clyde, where the North British does not penetrate, another part of the district served by the Caledonian is equally closely intersected by the lines of the Glasgow and South Western.

In this central district the coal traffic, both inland and for export, is of course very heavy, and the Caledonian has its full share. For the export trade much trouble has been taken lately to arrange that the coal, when it has been brought down to the docks, shall be loaded as quickly and cheaply as possible on to the steamers, with the result that some very elaborate and efficient machinery has been brought into use. One of the best equipped docks in this respect is the Rothesay Dock at Clydebank, belonging to the Clyde Trust, which is provided with a number of coal hoists of the most modern description. These hoists, which consist of huge frameworks of steel, containing immense lifts, stand at intervals by the water's edge, and measure some 80 or 90 feet in height. They are worked by electricity, the machinery being arranged at the top of the hoists, and the different movements are controlled by a man, sitting in a house just below the machinery, whence he has a good view of all that passes. The control is exercised by means of a single lever, which can be inserted into any one of several parallel slots; the backwards or forwards motion of this lever in the appropriate slot produces any desired result.

The coal trains having been brought into the dock premises by the railway, the wagons are hauled by a rope wound round an electric capstan to the weighing machine, where each wagon is weighed. The wagon is then run forward a few yards to an electric turn-table, where it is turned through the necessary angle, and then one end of the turn-table is elevated a few inches and so runs it on to the hoist; here it is locked in position by means of a bolt, which is shot out immediately behind the leading wheels, and so prevents them from running backwards. The hoist is then set in motion and the wagon raised to any point desired, and the coal is tipped into a shoot which extends outwards and downwards towards the hold of the vessel lying alongside. To carry out the tipping, a door at the outward end of the wagon is unfastened, and the landward end is raised through an angle of about 45 degrees, so that an avalanche of coal is discharged through the shoot, and in a few seconds the wagon is empty. It is then restored to a horizontal position, the door is closed, it is lowered to a railway line at a higher level than that on which it reached the hoist, the wheels are unlocked, and the wagon runs off the hoist by gravity on to a second weighing machine, where it is again weighed, and everything is ready for dealing with a fresh wagon. In this manner the hoist is capable of dealing with a wagon every minute, which, with wagons of the usual size, means that it can put on board ship 600 tons of coal an hour, but the difficulties of trimming the load make it impossible to maintain this speed for long together. The hoists are built for dealing with 30-ton wagons if necessary, but this is not often the case.

The cost of producing the electricity required for dealing with each wagon is generally about $\frac{3}{4}d$. It is generated in a power station belonging to the docks; although the demand for the hoists and other electrical machinery varies greatly from minute to minute, it has been found possible in this power station to dispense altogether with accumulators. This is achieved by the adoption of a patent system, the chief feature of which is an enormous fly-wheel turning at 375 revolutions a minute, in which a great reserve of energy is stored.

The imports of these docks largely consist of iron ore which, by means of electric cranes, is lifted in buckets from the holds of the vessels. Owing to the construction of the holds, and the presence of the tunnel containing the screw shaft, a great deal of the ore has to be dug out by manual labour. This was by no means a pleasant or easy job in the case of the heavy, sticky, wet ore, with which a ship, which I watched, was loaded, but was probably much better than dealing with the clouds of suffocating dust, which arise from this stuff when it is in a dry state.

In recent years the work of the railways in dealing with coal has been much complicated owing to the great refinements which have been introduced into the preparation of coal for the market. Between the time that the coal is raised to the surface, and that at which it leaves the colliery sidings, a great deal of work is done upon it at the pit's mouth in the way of cleaning it and dividing it up into different qualities and sizes. At a colliery which I visited the coal—which is lifted in the little trucks in which it has already travelled, perhaps a mile, underground, behind a pit pony or on a tramway worked by an endless rope—is first of all weighed by a clerk, and then slid down one of a number of shoots; the larger pieces, amounting to something over 50 per cent. of the whole, are caught on the way down by suitable sieves, and, after being picked over by hand by a number of boys and girls, are ready for loading into the railway wagons. The pieces of less than two inches cubed, known as dross, continue their descent, and, falling into railway wagons, are carried a few yards to a building containing the washing plant; here the wagons are tipped, and the dross is sucked up a pipe to the top of the building, and on its subsequent descent is, first of all, divided by a machine into four sizes and undergoes a process of washing, by which it is freed from stones and other heavy incombustible matter; finally, yet a fifth quality of coal, consisting of the finest particles, and containing a large admixture of fine earth and stone, is produced, which is principally used for working the winding engines of the colliery itself. What with the different qualities of coal coming from the different seams, or even from the same seam, and the different sizes into which the small coal is divided, one mine may produce coal which is sold under a dozen different descriptions; and as each description of coal has to be kept separate, and cannot therefore be transported in a wagon which contains any other size or quality, the difficulties which the railways experience in making up the coal trains and distributing the coal are very formidable.

Situated as Glasgow is, quite close to the beautiful shores of the Firth of Clyde, a very large part of the suburban traffic is conducted to and from the numerous little seaside towns on that estuary, and there is also in summer an enormous volume of tourist traffic to places beyond. In all of this traffic all three railways which serve Glasgow—the North British and Glasgow and South Western as well as the Caledonian—participate as fully as they can, and all of them have numerous steamers running in connection with their trains, which bring passengers from Glasgow down to various points of embarkation. The activities by land of the North British are almost entirely confined to the north bank of the Clyde, but on the opposite shore of the river, as well as further inland, the Caledonian finds itself hard pressed by the Glasgow and South Western, both of these lines serving a number of different points; from the various piers not the railway steamers only, but numerous others, ply in every direction across the more or less sheltered Firth and the land-locked waters which connect with it. The Coast traffic and most of the rest of the Caledonian's passenger traffic starts from Glasgow Central Station, where there is, besides the high-level terminus, an underground station, through which run many local trains. Only the north-bound trains running towards Perth make use of the old terminus at Buchanan Street, which, in comparison with the Central, is a mere shanty.

The Central Station, which was only opened in 1879, has since then been reconstructed twice; at its last reconstruction, which took place about a dozen years ago, it became so large as to rank as one of the very biggest stations in Great Britain, and the engineers were faced with all the problems, which arise in connection with the working of traffic on a very large scale, and have to be solved, in each case, on the lines which the space available and the local conditions render expedient.

As the Central Station is situated immediately to the north of the river Clyde, the provision of an adequate number of approach-lines involved the building of a very broad new bridge across the river, a task that was rendered doubly difficult by the insecure nature of the ground, in which the foundations had to be sunk.

Then, beyond the provision of adequate approaches to a big station, a most important point is that there must be, somewhere close by, a sufficient number of conveniently arranged sidings for storing rolling stock, from which the empty trains can be brought into the station as required, and to which they can be got out of the way directly they are no longer wanted, so as to be cleaned and prepared for their next journey. Space for these was found by utilising the site of the old Bridge Street station, just south of the river. In order to make the sidings as accessible as possible, they were arranged, not all next to one another, but in convenient positions beside the different running lines, to which some of them are connected at both ends.

Increased space for the station proper was secured partly by taking in more ground on the west and partly by lengthening the existing station towards the south, with the result that the area was about doubled. The shape of the space at the disposal of the designers was peculiar, because the railway company's hotel already occupied one corner of the station and made it impossible for the platforms on the west side to be carried so far north as those on the east, and a sudden contraction in the width of ground available, due to the fact that sufficient space could not be secured on the east side, made it impossible to carry some of the platforms as far to the south as was desirable. The result is that the north end of each successive platform stops short of the point reached by the one to the east of it, and that the platforms in the middle of the station have been made much shorter than those at either side. Under these circumstances, the general scheme of working is to use the platforms at either side

THE CONCOURSE, GLASGOW CENTRAL STATION.

for the long-distance trains, which are often comparatively long, and to devote the shorter platforms to the shorter local trains. In harmony with this arrangement, the cab-rank is placed between two of the longer platforms on the west side of the station, at which most of the long-distance trains arrive. One of the principal features of the station is the concourse or large open space, between the main booking offices and the ends of the platforms, which gives standing room for many thousands of people. Among the numerous offices, bookstalls, and waiting-rooms, which surround the concourse, is the Left Parcels Office, an institution which is highly appreciated by people who come into Glasgow to shop ; here, for a small payment, parcels may be sent from shops in the town, addressed to their purchasers, who call for them as they pass to their trains. A large indicator showing the platform at which each train will depart, is displayed high up on the side of one of the buildings flanking the concourse. It stands in such a manner as to be easily visible from the greater part of the concourse, where at times, when the number of passengers is very great, large crowds can congregate under shelter, and, with the help of the indications given, hold themselves in readiness for passing, as soon as the gates are opened, to the trains in which they desire to travel.

At the northern entrance the station is on a level with the street, but, owing to the natural descent of the ground towards the river, and the fact that the interior of the station has an upward slope for some distance from this entrance, the greater part of the passenger station lies high above the street, and there is a great deal of accommodation on a lower level, which is devoted to a number of objects, one of the most important being the handling of parcels and of luggage unaccompanied by its owners. Large receiving and sorting offices are supplemented by a passage leading right across the station transversely and connected with different points on the surface, and also with the low-level station, by means of a number of hydraulic hoists. In addition to the main entrance, access to the station is provided by means of stairways at a variety of convenient points, and a ramp for the entrance of empty cabs has been arranged below the dining-room and above the kitchen of the hotel. The cab-rank stretches the whole length of the main arrival platform ; an extension of this platform, conveniently remote from the rest of the station, is used for dealing with fish, fruit and milk, and road vehicles have easy access to it along the cab-rank.

The signalling of the trains into and out of such a station as the Central is a matter of great complication, and, as a train, entering by any one of the approach lines, can be turned into any platform, the number of different indications that it must be possible to give the drivers is considerable. Under these circumstances, the extreme simplicity of the signals is very remarkable. At the entrance to the station there are only two signals (one below the other) for each approach line, and, if it were not for the fact that some of the platforms are long enough to take two trains, one behind the other, only one signal for each line would be necessary. If the platform, at which the train is to draw up, is free, the top signal is lowered ; if a train is already standing at the north end of it, leaving the south end free, the bottom signal is lowered. The number of the

SIGNALS, GLASGOW CENTRAL STATION.

platform, for which the points are set, is made known to the driver by means of large figures (illuminated by night) which are displayed below the signal, or signals, which allow him to proceed. The signals and indicating figures are interlocked with circuit-breakers, which are arranged at intervals along the rails ; and these circuit breakers, by the fact that they are depressed by the flanges of the wheels of any train standing upon them, bear continuous witness to the presence of that train. The single box, from which the signals and the 130 odd sets of points are worked, stands upon the side of the new bridge. An electro-pneumatic system of moving the signals and points is in use ; the movement of any lever in the signal box actuates, by means of electricity, a valve situated close to the points or the signal which it is desired to move ; and the movements of the valve in turn admit compressed air to, or release it from, a cylinder from which the actual movement of the points or the signal is effected. By the use of this system all the usual point rods and signal wires are dispensed with ; much space is saved, particularly on the bridge, where space is extremely valuable, while, inside the signal box, it has been found possible to install the 337 levers in a frame little more than 80 feet long.

Big as the station is, the company, from its experience of the remarkable development of traffic which has taken place in the past, is fully aware that at no distant date it may be necessary to make it yet bigger. The station has, therefore, been so built that, when the time arrives, it will be possible to carry out a further enlargement on the west side, where there is space available for several more platforms to be added to the existing ones. This will be done in such a manner that the further extension will harmonise completely with the present building. The bridge over the Clyde was constructed with this eventuality in view, and will want no alteration when it is decided to proceed with the new work.

Though the Central is certainly the most remarkable station in Glasgow, St. Enoch's, which, with its lofty single arch roof, is a great contrast to the Central, is also a station by no means unworthy of a great city. As for the North British, its Glasgow terminus at Queen Street (High Level) is in size and convenience a very long way behind both the Central and St. Enoch's. The main line from Glasgow starts northwards, where the ground rises very steeply, and, consequently, immediately on leaving the terminus, a longish ascent at 1 in 45 is encountered, a good part of which is in tunnel. For many years the trains were worked in and out of Queen Street by means of a stationary engine and a rope, but this has now been given up in favour of ordinary locomotives, and the trains are helped up the incline by powerful tank engines. If the traffic in and out of Queen Street (High Level) were anything like that dealt with by the Caledonian at the Central, this very awkward approach would be a serious handicap; as is the case with the Caledonian at the Central, a great part of the North British's passenger traffic does not use the high-level station at all, but traverses Glasgow from east to west by means of an underground line, which passes through Queen Street station at right angles to the high level line.

Beyond the great work at Glasgow Central, a good deal of reconstruction has lately been, or is, proceeding on the Caledonian, particularly at Stirling, Carstairs, and Buchanan Street stations, and the improvements, which have been going on at Aberdeen, have now entered upon their last stage—the rebuilding of the present station on a much larger scale. For some years now the Caledonian has been engaged in improving and extending its property in Aberdeen. The approach lines have been widened, a new goods station of modern design has been erected, the running shed has been extended, and the big bridge across the Dee has just been rebuilt. The new station which, like the old, will be owned jointly with the Great North of Scotland Railway, will cover considerably more ground than the present station and contain about double the accommodation.

Though the populous parts of Scotland are well supplied with railways, directly they are left behind the traveller reaches districts where railways are not looked upon as a matter of course. Here, rather, he has to be thankful that railways exist at all, and any company which has built a railway must be looked on as a public benefactor. Prolonged shunting operations at every second station are quite normal incidents of the journey, and, if necessary, half a dozen trucks of coal are attached to the rear of a passenger train, whose occupants are expected to overlook the bumping, which they consequently receive every time the train stops. If no member of the station staff is unoccupied, one of the ladies of the stationmaster's family is turned on to examine the tickets, and a free and easy feeling characterises all the proceedings. In these remote places, no doubt, the traffic is, owing to the paucity of the population, of strictly limited extent, and to make the railway pay, or, indeed, not lose heavily, the adoption of every species of economy is of importance. A large capital expenditure is out of the question, so the line is single and tunnels are almost completely avoided, the line closely follows the surface of the country, and the steep hills, which have to be surmounted, are overcome by taking a winding course. All this vastly increases the difficulties of working, and the chances of unpunctuality, with its attendant evils; but, when these evils are forced upon the attention, it is only fair to compare things with what they would be if the railway did not exist at all, rather than contrast the shortcomings of an unfavourably situated little company with the efficiency of the more fortunate trunk lines. The most conspicuous instance in Great Britain of a line built through the wilderness is the Highland Railway, whose main line stretches 279 miles through country which is to all intents devoid of industries, and is to a great extent devoid also of agriculture. No doubt its construction was primarily due to the great landlords, who wanted a means of access to their estates, and it would hardly have been undertaken at all if the summer attractions of the Highlands had not promised to produce a considerable pleasure traffic, which would partially offset the exceeding barrenness of the country traversed. A railway of this kind cannot be looked on as a strictly commercial undertaking, and its founders no doubt regarded it as a convenience, for which they were, in the last resort, ready to pay, without hoping for much direct return on their capital.

The busy station of Perth is the point whence the Highland trains start on their long journey into the wilds. Next to Carlisle and York, Perth is probably the most remarkable junction in the British Isles. It is true that only three railway companies run their engines into it, but the variety of passenger stock which passes through is very great, as it is here that the East Coast, West Coast, and Midland routes to Scotland all converge to contribute their share of the traffic which proceeds to the Far North by way of the Highland Railway.

CHAPTER IV

THE RAILWAYS TO THE WEST

Great Western Railway—Railway Gauges—Great Western Engines—Water Softening—Long Runs—Slip Carriages—Rail Motors—Permanent Way—South Western Railway—Goods Station at Nine Elms—Princetown Railway—Southampton Docks—Eastleigh Works—Signals—Engine Drivers—Single Line Working—Brakes—Tenders.

The Great Western, like all other big British railways, is an amalgamation of a considerable number of lines. Owing to the geographical formation of the West Country, and to other causes, the lines forming the Great Western system were formerly exceptionally scattered, and a large number of extremely expensive new railways were necessary in order to link up the different districts, in which these lines lay. Some twenty-five years ago the Great Western, which had the greatest mileage of any company in Great Britain, had hardly a single really direct route from London to any town of first-rate importance, and, where there were two routes, the Great Western one was invariably the longer. The North Western route to Birmingham, and the South Western route to Exeter and to Plymouth were 15 to 20 miles shorter than those of the Great Western, the important South Wales district was cut off from direct communication with Bristol and London by the estuary of the Severn, and had no really good connection with Birmingham, and, even between London and Bristol, where there was a direct line, the trains took some quarter of an hour longer than necessary because of an old contract, whereby the railway company had bound itself to the owner of the Swindon refreshment rooms to stop all the trains there for ten minutes. In addition to all this some of the lines were broad gauge, and, though over a good many of them a third rail had been laid down to accommodate standard gauge rolling stock, the existence of two gauges greatly increased the difficulty of working the line. Such, then, was the position which the management had to change in order to make the Great Western the compact and easily worked system, which it now is, and, step by step, all the old obstacles were removed till to-day the line is among the leading railways of the world. The first work of magnitude that was undertaken was the construction of the Severn Tunnel, linking up the two banks of the estuary of that river. Next, in 1892, the last of the broad gauge lines were converted to narrow gauge, and the use of broad gauge rolling stock ceased for ever. The next step was the purchase, in 1895, of the remainder of the lease of the Swindon refreshment rooms, and from that date many of the express trains began to run through Swindon, saving much time thereby. The price paid was £100,000. Beyond this, four important short-cuts were taken in hand. Firstly, a line was built leaving the main line some miles beyond Swindon and running direct to the Severn Tunnel, shortening the distance to South Wales by about 11 miles, and also giving an alternative route for part of the way between London and Bristol slightly shorter than the original main line through the Box tunnel. Secondly, by building two new lengths of line and bringing up to the requirements of main line traffic other lengths of existing line, a new route was made to Exeter and the west. This route leaves the old main line at Reading and rejoins it near Taunton. It saves rather more than 20 miles, and makes the Great Western route to Plymouth shorter than that of the South Western. Thirdly, by short lengths of new line, a greatly improved route was provided between Birmingham and South Wales and Bristol; and, fourthly, two lengths of new line between Acton and a point north of Oxford have given a new route from Paddington to Birmingham, two or three miles shorter than that of the North Western. The opening of the new route to Ireland, by way of Fishguard, has also to be credited to the enterprise of the Great Western during the same period.

With all the recent developments, the Great Western traffic to and from London has naturally not ceased to grow, and corresponding improvements and extensions have had to be taken in hand in the London district. The old engine-shed at Westbourne Park was removed some years ago, and the engines now find more extensive accommodation in the new sheds at Old Oak Common; and the remodelling and extension of Paddington Station, and the railway approaches thereto, are being gradually proceeded with. Except for the platforms being some distance below the level of the street, there is little fault to be found with the arrangements at Paddington. The station is compact, yet fairly spacious, and it is one of the few where there are adequate means of passing from one platform to another. It is to be hoped that in the extension it will be found possible to preserve these good features, though the apparent endlessness of the new addition to No. 1 Departure Platform suggests that rather long and tiring walks may have to be taken.

The existence for many decades of broad gauge lines on the Great Western long kept alive in this country a discussion as to what constituted, theoretically, the best railway gauge, from the points of view of both safety and economy.

As regards safety, the standard gauge has turned out to be sufficiently wide to take engines and carriages having the highest centres of gravity. In early days, when the engines were very small, their centre of gravity was naturally low. It is obvious that the lower the centre of gravity the less chance there is of the engines overturning, and for this reason a low centre of gravity was held to be conducive to safety. As more and more powerful engines were required, necessitating bigger boilers, and, in some cases, bigger wheels, the centre line of the boiler had to be raised more and more, either to clear the axles or cranks, or on account of the boiler's own greater diameter, which eventually reached a point when it was impossible any longer to get it in between the wheels, so that it had to be raised above them. Each step involved a higher centre of gravity for the whole engine, and the progress which has been realised in the power of engines, has been made possible only by the recognition of the fact that such increased height is not dangerous. In a locomotive a great deal of the weight is placed very low down—the frames, cylinders and wheels are all very heavy—and the boiler is much lighter than its appearance would suggest, so that in engines with quite high-pitched boilers the centre of gravity and the rails still make approximately an equilateral triangle. On a line which is straight it does not matter much what the height of the centre of gravity is, but on curves, within the limits attainable, the higher it is the better. When passing round a curve the engine exerts a certain strain upon the outer rail, tending to push it outwards. The direction, whence the push comes, is from the centre of gravity of the engine, and therefore the higher this point is, the more does the strain come upon the rail from above and the less likely is it to burst the road. In electric locomotives the centre of gravity can be, and generally is, placed very low indeed, and, in America, at least one serious accident has occurred through the roads being burst by engines of this type. So much is this danger to be feared that in some recent electric engines considerable complications have been introduced with the object of raising the centre of gravity to the same height as in steam locomotives.

As regards economy, the standard gauge of British railways had, from the nature of the case, to be fixed before anything could be accurately known of future requirements, and was therefore a step in the dark. If railways could be begun again, there is little doubt that a wider gauge would be chosen, but, owing to the fact that it has been found not merely possible, but also advantageous, to build railway vehicles much higher and wider than would at one time have been considered safe, the distance between the rails (4 ft. 8½ ins.) has been found sufficient. What, indeed, has limited the full development of British railway vehicles is the comparatively small dimensions of the tunnels and the little space left by the platforms and bridges. In most other countries the gauge of the rails is the same, but more, sometimes much more, space has been left at the sides and above, and vehicles much higher and wider than would pass the British loading gauge are successfully run. As the loading gauge is, so is it likely to remain, for it is almost inconceivable that any radical reconstruction of British railways could take place so as to admit of the use of much higher and wider vehicles; and, although some scheming is required, everything that is really necessary can be done with the existing loading gauge. But, that the existing gauge of the rails has turned out to be fairly adequate, is due more to good luck than to foresight. If the dimensions of existing railway vehicles had been foreseen, it is certain that in early days a wider gauge would have been thought necessary to carry them. As it is, the 4 ft. 8½ in. gauge is, and probably will continue to be, just sufficient, though not by any means ample, for the requirements of locomotive and carriage designing, while that it is adequate as regards the speed and weight of the trains, is evident from the fact that the limit in neither of these particulars has, in this country, so far been nearly reached in every-day work. But, if railways could be begun over again in the light of modern experience, it is almost certain that not only a wider gauge of the rails, but also a bigger loading gauge, would be chosen. Increased economy has been made possible in ocean transport by the construction of larger and larger vessels, and the larger the vessel the greater the economy appears to be. Up to the present time, the standard gauge and the head-room available have been sufficient to render somewhat analogous economies possible in railway transport, but bigger dimensions would have made progress easier, and, therefore, almost certainly faster than it has been. In the United States, indeed, where many of the trains are as long and heavy as possible, so great an authority as Mr. Harriman appears to have thought that a wider gauge with still more head-room might have to be adopted sooner or later. But the railways of Great Britain, where trains of all kinds are comparatively light and fast, would have less to gain than those of other countries from being able to run extremely heavy trains, so, though it is certainly to be regretted that there is not a little more head-room for engines and passenger vehicles like corridor carriages and sleeping carriages, there is not very much fault to be found with the 4 ft. 8½ in. gauge of the rails.

For more than forty years the broad gauge expresses were worked by engines with single driving-wheels, 8 ft. in diameter—on account of their long service, one of the most celebrated classes of engine that has ever existed. As the broad gauge allowed ample room in every direction the task of the designers was much facilitated and the engines were simple, compact, and powerful, and suffered in no way from any of their parts being cramped. They ran on eight wheels, there being two pairs of carrying wheels in front of, and one behind, the driving wheels. The total wheel-base was only 18 ft.—equivalent to one of 12 ft. on the standard gauge—and, as there was thus no difficulty in the matter of rounding curves, no special arrangements were necessary to give flexibility, and so all the axle-boxes were fitted direct to the main frames. With inside cylinders only 18 ins. by 24 ins., a gauge of 7 ft., and a comparatively slow movement of the reciprocating

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(2)

GREAT WESTERN RAILWAY: (1) 4–6–0, 4-CYLINDER EXPRESS ENGINE (2) BROAD GAUGE SINGLE.

parts owing to the large diameter of the driving-wheels, these engines possessed also great stability, and at that early period, when they were first introduced, were little less than works of genius. They were modified slightly as time went on, but there was little real difference between the first engines of the class and those which were working in the last days of the broad gauge. Much as we may admire the ability of the designers of the first engines, it is a sorry commentary on the enterprise of the Great Western during that time that the trains had improved so little in the intervening years as to leave the engines, which worked them in the '40's, still good enough to work them in the '90's. Since the abolition of the broad gauge, the locomotive designing of the Great Western has, like almost everything else connected with that railway, made great strides, as may be seen by an inspection of one of the engines used for working those expresses, which now make the Great Western famous throughout the world. Big and imposing she is, though not perhaps so pleasing in outline as British engines generally are. Of her efficiency there can be no doubt. Consider how every detail has been thought out, and how many well-attested improvements have been applied. Some railways do not like employing a steam pressure in the boiler higher than 175 lbs. per square inch, but for this engine and her sisters the Great Western boiler-makers have to make boilers, which will keep tight with 225 lbs.; and this makes the engines both more powerful and more elastic—if they are called upon to make a special effort they may use steam faster than they can make it till the pressure is reduced to 175 lbs., and still be as well off for steam as engines whose safety valves blow off at that point. Her six-coupled wheels, of the same diameter as are given to four-coupled express engines, allow her to reach the highest speeds without the indefinable effort of movement, which is noticed in engines with small wheels, and, as there is at the same time more than fifty tons' weight on the coupled wheels, she is able to gain, or regain, speed * very rapidly, and to climb hills well. On the important West of England trains both these qualities are of great use, as there are some half-dozen stations between Paddington and Plymouth through which the trains have to slow down, and on the South Devon section of the line between Newton Abbot and Plymouth, the gradients in some places are so steep that the heavier trains are sometimes actually more than a four-coupled engine could undertake at all with any certainty of not coming to a stand. Worst of all is the Hemerdon bank,† which the up-trains from Plymouth encounter at the very beginning of their journey. This ascent is more than two miles long, and the gradient is 1 in 42 and 1 in 43; it is nearly twice as steep as the Beattock bank on the Caledonian, and is certainly the most formidable obstacle met with on any of the more important British main lines. Taking the maximum pull that the pistons can exert, without

* I once had a very good opportunity of comparing the powers of a four-coupled and a six-coupled engine (of almost precisely the same weights) of getting rapidly into speed with heavy trains, when both engines were doing approximately their best. The six-coupled engine with a train of 310 tons took 120 seconds to cover the first ½ mile. The next day the four-coupled engine, working the same train with 300 tons, under substantially similar conditions, took 147 seconds for the same distance. This was not on the Great Western.

† In other parts of the South Devon line the gradients are very slightly steeper, but for much shorter distances.

skidding the wheels, as $\frac{1}{5}$ of the adhesion weight, we find that engines of this kind can exert a pull of about 10 tons, and can therefore just struggle up 1 in 42 with 250 tons behind the tender. If only four of the wheels were coupled, the train load would, under the same conditions, have to be reduced to about 125 tons.

The efficiency of the boiler is increased by the application of a superheater of the Swindon type, which, though it does not raise the temperature of the steam to nearly the same extent as does the Schmidt design, has nevertheless proved of value.

As these engines are often obliged to exert a high power for long periods together, the strain on the machinery is considerable. In order to reduce this strain, the ordinary arrangement of two cylinders is, in some cases, replaced by an arrangement involving the use of four much smaller cylinders—two inside the frames, driving the first coupled axle, and two outside, driving the second coupled axle. The driving stresses are in this way much diminished. Beyond this, a yet more important advantage is secured in that the cranks are so arranged that the pistons of the inside and the outside cylinders on either side of the engine are made always to move in opposite directions and so approximately to balance one another. This makes it unnecessary to put into the driving wheels balance weights of the kind that are used in 2-cylinder engines, which, much to the detriment of the permanent way, once in every revolution of the wheels increase the weight which the rail has to support. Another device tending to spare the permanent way is the connecting together by means of equalising levers, of the springs of all the coupled wheels, which prevents any one pair of wheels from ever supporting more than its allotted share of the weight of the engine.

Some years ago, before the present standard designs of express engines were evolved, the Great Western took the unusual step of importing several engines from France. In 1900, the Chemin de fer du Nord had brought out a 4-cylinder compound engine with the 4-4-2 arrangement of wheels, the performances of which were so remarkable that they attracted the widest attention in many other countries besides France. The Nord soon multiplied the type, and other French railways adopted it, always with the most satisfactory results, so after a time the Great Western, which was rapidly improving its trains, and was feeling the need for more and more powerful engines, imported from France an engine precisely like the Nord engines, and then, a year or two later, two similar, but slightly bigger engines of the same pattern as some built for the French Paris-Orleans line. Though this experiment did not result in the full adoption of the French design, these engines seem always to have done very good work, and the employment, in one of the now standard types of Great Western express engine, of various prominent features of the French engines—four cylinders with balanced reciprocating parts, Walschaerts' valve-gear, and the high boiler pressure of 225 lbs. per square inch—is no doubt, in part at least, due to these importations.

The Great Western has the distinction of possessing what is at the present time the largest engine in Great Britain. This engine, "The Great Bear," is not unlike the other 4-cylinder six-coupled express engines, but she is bigger throughout, and has an extra pair of small

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GREAT WESTERN RAILWAY: (1) LATEST TYPE OF PASSENGER CARRIAGE; (2) RAIL MOTOR AND TRAILER.

trailing wheels to support a fire-box of the wide variety. Although " The Great Bear " was put to work in 1908, no more engines of the type have yet appeared. There does not, indeed, appear to be any work on the Great Western which cannot be performed quite satisfactorily by the smaller engines, and, till more is demanded of the engines, it is useless to provide machines so powerful. This state of affairs is probably due to the comparatively good quality of the fuel burned in Great Britain, which enables engines with not more than ten wheels to do everything that is wanted, whereas in America much larger engines with twelve wheels have long been common, and there are a good many such machines in use on the Continent of Europe.

If the locomotives of the Great Western perform the hardest work in England in a thoroughly satisfactory manner, the newest rolling stock which runs on the principal expresses is equally admirable as far as ease and smoothness of running are concerned, though, unfortunately, the space allowed each passenger is not quite so liberally measured as might be desired.

The Great Western, possibly owing to the high pressures employed in a good many of the boilers, has gone in largely for softening the water chemically before it is supplied to the engines. One big installation is situated near Goring on the main line to Bristol for filling the water troughs, which are there laid down on all four lines. The plant consists of an engine-house, in which is an engine for pumping the water, and two steel towers about fifty feet high, in which the softening process takes place. The principal impurity found in the Goring water is carbonate of lime, and, for precipitating this, quick-lime dissolved in water is employed. A mixture in the right proportions, ascertained by periodical chemical tests, is made at the top of one of the towers, and once in twelve hours the charge is passed down to the bottom of the tower and up again through pipes, in which it gets thoroughly mixed with more water, till a liquid is produced the colour of milk (known as milk of lime). This is added gradually to the hard water, which is continually being pumped up to the top of the first tower. The water is then directed down a pipe in the middle of the adjoining tower, from the bottom of which it rises again through a number of pipes, in which are placed spiral plates, which offer a very large surface for the deposit of the impurities which the chemical action of the milk of lime has precipitated. The softened water, after passing out from the tops of these pipes, through which it has slowly ascended, rises through a filter, which collects any solid matter that may not have been precipitated on to the spiral plates, and thence runs away from the top of the second tower into the reservoir, whence it is drawn upon, as required. Nearly half a million gallons of soft water—that is well over two thousand tons—are required on a normal day. All this water does not, however, find its way into the tenders, as a great deal is spilled during the process of picking up water at speed—so much, indeed, that it has been found worth while to collect as much of the overflow as possible, and lead it back by a special pipe to the well, from which the hard water is drawn.

The Great Western, ever since it got rid of the Swindon stop, has been noted for the number of long runs which its engines perform. Directly the stop at Swindon was cut out some of the trains began to run

GREAT WESTERN RAILWAY, WATER-SOFTENING PLANT.

through to Bristol (118¼ miles via Bath); soon afterwards runs to Exeter (194 miles) were introduced; and for a year or two before the opening of the line to the West, via Westbury, the 246 miles between Paddington and Plymouth, via Bristol, used to be run without a stop. The distance to Plymouth has now been reduced to 225¾ miles, but this still gives the Great Western the longest non-stop run in the world, though the North Western and Midland, which in summer both have runs of over 200 miles, are not far behind. The runs performed on the Plymouth line are longer than those found on the other main lines of the Great Western, but along all its principal lines there are a considerable number of trains running distances of well over 100 miles without a stop. All over England, indeed, such runs are much more numerous than are to be found in any other country. Considering the relatively small area of England, this is, at first sight, rather a remarkable fact. Looked at a little closer, it is less surprising. The circumstances which create a demand for long non-stop runs are the existence of very large towns, which can provide train loads of people all of whom wish to perform one particular journey; and England, with her large urban populations widely distributed at considerable distances from the Metropolis, but at the same time close enough not to make the time necessary to complete the journey a serious deterrent, offers conditions which are very favourable to the development of long-distance non-stop runs. In America and on the Continent of Europe, where the conditions are different, the number of such runs is much smaller. The Prussian State Railways have lately put on a fair number of trains making very long runs;

there is one train each way between Berlin and Hamburg which covers the 178¼ miles separating those cities without a stop, and for some time trains have run each way daily between Berlin and Hanover (158 miles) also without a stop. In France there is no regular run of so much as 150 miles without a stop, and in America, though some of the New York-Chicago expresses perform very long runs, the total number of such runs is not great.

As the length of run performed without a stop increases, so also do the difficulties of serving intermediate stations, at which the express trains do not call. When the number of long runs performed on the Great Western is considered, it is not surprising to find that this line is the one on which the practice of slipping carriages at speed has reached its greatest development. Particularly is this the case with the West of England expresses, from which Westbury, Taunton, and Exeter all receive slips. Many people living at intermediate places along this line have to deplore the impossibility of attaching carriages at speed in the same way as they are detached, for they find the up journey a much longer and more tiresome business than the down journey.

A serious attempt has been made during the last few years to increase local traffic by running rail-motors, or short trains so arranged that they can be driven from either end without any change in the position of the locomotive, which is sometimes placed at one end and sometimes in between two carriages. The Great Western has been particularly active in introducing rail-motors. They are very easy and convenient to handle, and quite cheap to build and keep

GREAT WESTERN RAILWAY, GORING WATER TROUGHS.

in repair. Beyond this the principal advantage which they offer is that the passengers can be taken up or set down at places where it would not pay to build a regular station. A short, cheap wooden platform, with no booking office and no station staff, is all that is required, and, in some cases, even this can be dispensed with, and the passengers taken up or set down at a level crossing or other convenient point, in a manner which would be impossible, or at least highly undesirable, with an ordinary train. In this manner it is possible to give facilities for short-distance journeys, which would otherwise either not be made at all, or be made by some means other than by rail. A considerable part, therefore, of the traffic conducted in motor vehicles must be regarded as entirely new traffic, which, so far as the railways are concerned, would otherwise not have existed at all. The distances covered being short, and the passengers, from the nature of the case, few, the conditions are simplified as much as possible in every way, and one class has to suffice. Motor vehicles are, indeed, less part of the ordinary train service than glorified omnibuses, which are introduced to give extra facilities in certain special places, where there happens to be a sphere of usefulness for them. But that the number of places, where they can profitably be used, is considerable, is shown by the numbers which have been introduced since the feasibility of the system was recognised.

When the Great Western finally got rid of the broad gauge, it had the opportunity of making to some extent a fresh start, and, in order to ensure a really prosperous future, it seems to have made up its mind to a bold expenditure of capital in every direction, where such expenditure promised a good return. One of the things which it determined to have was first-class permanent way, and it may confidently be said that the new permanent way laid during recent years on various parts of the Great Western is unsurpassed.

There is a great deal of difference between permanent way which is perfectly safe, and permanent way which, besides being safe, is really good. The former is the indispensable minimum, universally attained in this country, but it is only necessary to travel about on the different lines to discover that some approach the latter standard much more closely than others. The extra expense necessary to lay down permanent way of the latter class is considerable, and though, regarded as an investment, it is sure in the end to bring in a handsome return, railway companies sometimes shrink from incurring it. In comparison with a merely safe permanent way, a really good and well-kept permanent way enables an engine to haul heavier trains with the same expenditure of fuel, occasions less wear and tear to the rolling stock, is pleasanter to travel upon, and cheaper to maintain.

In early days various forms of permanent way were tried, but now for a long time the only sort of road used in Great Britain is the familiar one, in which the rails are supported in chairs fixed to transverse sleepers, and secured in the chairs by means of wooden keys. Except for one thing, this form of road seems to be as good as any that could be devised. That one thing is the joint connecting the ends of the rails, and this—a weak spot in any kind of permanent way—is, perhaps, slightly more troublesome in a chair road than in a road laid with flat-footed rails. In a perfect road the joint would be as strong as the rest of the rail, and there would be no bump as the wheel passed over it. Though inventors by the score have produced new forms of joint, none has ever yet satisfied these requirements, and the ordinary fishplates are still almost universally used, the only important difference between the different kinds being that some are longer than others. As the longer ones work with a more advantageous leverage, they are somewhat the more efficient, but, whereas when flat-footed rails are used, as in America and over the greater part of the Continent of Europe, it is possible to use fishplates of any required length, in British roads the presence of chairs used to support the bull-headed rails, makes it difficult to use any but quite short fishplates. Remedies do indeed exist for this ; one form of remedy, for instance, is applied on certain foreign railways, which use a chair road. It consists in the use, on the sleepers on either side the joint, of chairs with jaws wide enough to embrace both the rail and the fishplates, together with the usual wooden key. A certain complication is thereby introduced, as two patterns of chair are necessary, but this is a very small matter, and, as some arrangement of this kind is a fairly simple way of increasing the strength of the weakest part of the road, it is likely to be more widely used than it is at present. But practically all that is now done in England to increase the strength of the joint is, in some cases, to lay the sleepers on either side of it nearer together than the rest of the sleepers are laid, and to use extra big sleepers in these positions. No fishplates, however, which are now employed anywhere provide anything like a perfect road, and the rail joints are one of the very few things connected with railways which are still conspicuously defective. Three-quarters of the fatigue of travelling is due to the endless succession of bumps, of which imperfect rail-joints are the cause, and a large part of the wear and tear of both road and rolling stock is due to the same thing. If it is not possible to affirm that a perfect rail-joint will never be found, it is at least safe to say that nothing of the kind has so far come to the fore; and there are very great difficulties in the way of the inventor, as any considerable complication is clearly inadmissible.

Fishplates are designed so as to make the joints as strong as the rails which they connect together, and, theoretically at least, when the joints are in good order, the form of the wave-like depressions made in the rail by the trains is almost exactly the same when they pass through the joint, as it is at every other point in their paths. But, however this may be in theory, in practice the unpleasant bump of each wheel as it crosses each joint, is always more or less perceptible.

In old days the rails were made of wrought iron, but, now for a long time, steel has been the only material employed. Steel is made in different ways—almost always by some variety of the "open hearth" process—but the object of all is of course to produce a metal of the required hardness and toughness; this result is attained partly by attention to the chemical composition of the metal, and partly also by arranging that, while its temperature is between certain limits, it shall undergo an adequate amount of compression between the rolls of the rolling mills. Rail steel is iron which contains small quantities of other elements—carbon is the principal hardening agent, and there are also various other things, which have more or less valuable effects. The amounts of all these ingredients have to be very carefully regulated, as, in almost every case, an excess or deficiency would have very undesirable results. A good many endeavours have lately been made to produce steel which will cause the rails to take longer to wear away than is now the case, and, for this purpose, variations are made in the process of manufacture, some of which involve the use of an additional ingredient, like chromium or nickel. There is no doubt that some of these special steels show great resistance to wear, and in particular places, where the wear of ordinary rails is excessive, offer considerable possibilities of economy.

Since the inception of railways there has been a continuous tendency toward the employment of longer and longer rails, and of late this tendency has been a very marked one, the length in many cases having been increased from 30 ft. to 36, 45 and even 60 ft. This, of course, correspondingly decreases the number of rail-joints, though, as the intervals left for the expansion of the rails by heat have to be increased, the ends of the rails may get a little more knocked about. If it were not for the necessity of allowing for expansion, it would be a fairly simple matter to weld together the ends of adjoining rails, and so get rid of rail-joints altogether; and, who knows but that some genius may arise who will discover a steel alloy which does not expand when heated?

The bull-headed rail, in almost universal use in Great Britain, has two heads; the upper one is large and heavy and so designed as to allow it to be much worn away before it is sufficiently weakened to render it no longer serviceable; the lower one, equally broad, has less depth, and serves to support the rail in the chairs. The total depth of a heavy modern rail is usually about $5\frac{3}{4}$ ins. The rails are laid to lean inwards, with an inclination of 1 in 20, so as to correspond to the conical shape of the wheel flanges. For curves of large, or fairly large, radius, the rails are not bent, and, in reality, form series of tangents to a circle.

The weight of the rails, though at first sight the most important element in the strength of the road, is really, within fairly wide limits, a matter of minor concern. On main lines, rails weighing, when new, anything from 90 lbs. to 100 lbs. a yard are employed, and, as they may all be worn down to well under 80 lbs. a yard, and still be capable of supporting the heaviest trains, there is in all cases a wide margin of strength. The Midland and Great Northern are the lines which use the heaviest rails, both having a 100-lb. type. There are, however, certain places like the Forth Bridge, where specially designed rails of yet greater weight are in use. The greater the weight and strength of the rails, the greater the factor of safety; and the weight and strength of those used in British roads compares not unfavourably with the weight and strength of those used in other countries. As a considerable part of the metal of a flat-footed rail is utilised to form the broad foot, which adds very little to the rails' stiffness, bull-headed rails must be stronger, weight for weight, than flat-footed rails. Nevertheless, the weight per yard of the bull-headed rails used in Great Britain, is generally greater than that of the flat-footed rails used on the Continent, and about the same as that of the flat-footed rails used on the best laid lines in the United States. On the Continent the maximum stress, to which rails may be subjected, is somewhat less than is allowed in Great Britain, and is roughly in proportion to the smaller strength of the rails, but in the United States the rails are allowed to undergo maximum stresses at least 30 per cent. greater, weight for weight, than is allowed in Great Britain.

Some years ago it became apparent that there was in practice so little difference between the advantages offered by the different sections of rails most generally in use in Great Britain that standard sections of rails of different weights might be designed with a good prospect of their being widely used. This was therefore done, and at the present time a good many companies use rails of these standard designs.

The best British permanent way has always been celebrated for its solidity and the smooth running which it affords. The reason for this is not far to seek, and is found in an ample margin of strength in the principal elements that go to make up the road. The wheels of the train are supported upon the rail, the rail rests upon the chairs, the chairs are secured to the sleepers, and the sleepers are imbedded in the ballast. Good ballast is, therefore, the first necessity for a good road. It must be thick enough properly to distribute the weight of a passing train over the whole subsoil, elastic enough to give the smoothest possible running, binding enough to prevent the least horizontal movements of the sleepers, and of such a nature as to retain no moisture in itself, and to allow rain to drain off rapidly. The sleepers must rest firmly on the ballast at both ends, but not in the middle, so that each one supports its full load without any tendency to swing like a see-saw round a fulcrum; they must be big and strong enough to support the loads put upon them; elastic enough to deaden vibration; and impervious to wet so as not to rot. When all these conditions are assured, the chairs and the rails, which they hold, stand on a really satisfactory base, and the train hums along serenely. Of all the various materials, of which the very important ballast is composed, none is so well beloved of the permanent way engineer as clean, hard, broken stone, which possesses in a high degree a combination of the desirable qualities enumerated, and, although expensive, is almost always worth using on lines where the traffic is heavy. The bottom layer of ballast is usually composed of large heavy stones, carefully packed by hand.

When railways were first introduced a great deal of experimenting with different forms of permanent way was necessary before it could be decided which were the most practical forms to use. Patterns of rail, which should give great stiffness, together with enough bearing surface for the wheels above and the supports below were by no means at once evolved, while the most advantageous method of laying the sleepers was up to comparatively recent times, a matter of controversy. Longitudinal sleepers will probably never again be used, except in special places, but for a long time the supposed advantages of affording continuous support to the rails led to their being extensively used in some parts of the world, and the proverbially smooth running of the old broad gauge trains on the Great Western is sufficient evidence that a very good road can be constructed with them. The comparatively unwieldy longitudinal sleepers are, however, much more difficult to lay and to renew than are the easily-handled transverse sleepers, and there are several other advantages of some value possessed by the latter. As each transverse sleeper is secured to both rails, it is a most effective means of preventing the road from spreading, whereas longitudinal sleepers have to be specially braced together at intervals for this purpose. Then, one of the first requirements for a good permanent way is that the drainage of water should be complete. Transverse sleepers offer no hindrance to efficient drainage, but longitudinal sleepers, by pressing down the ballast immediately underneath them, tend to prevent the free escape of the rain which falls between the rails.

In British permanent way the sleepers used are unusually thick and heavy, but not so closely spaced as is customary in foreign countries, where flat-footed rails are in use. Owing to the comparatively high price of timber in Great Britain, it is always found economical to impregnate the sleepers with creosote, which process about doubles their life without nearly doubling their cost. The use of creosote has another important result, as it has the effect of giving the sleepers a life approximately as long as that of the rails which they support, so that, when the sleepers are worn out, the rails are worn out also, and both can be renewed together at one operation.

The almost universal use of chairs in Great Britain is to some extent due to the softness of the wood, of which the sleepers are made; the wood is generally white fir. The softness of the sleepers makes it necessary to give the rails a greater bearing surface on the sleeper than would be provided by flat-footed rails, and so chairs are interposed for the purpose. Flat-footed rails can, indeed, be provided with an augmented bearing surface without the use of chairs, if flat steel plates are laid between rail and sleeper. Steel plates are, however, almost as much of a complication as chairs, while they are without the great advantage, which the latter have, of allowing the rails to be taken out and replaced quickly and easily. They are also rather inclined to clatter.

An important point in the construction of a solid road is to fasten the chairs as firmly as possible to the sleepers. There is always a very small amount of play between the two, but much can be done to reduce this play to the smallest limits. One of the best arrangements so far adopted is in use on the Great Western. The chair is cast with serrations below, which engage with corresponding serrations on the sleeper, and is fixed down under a pressure as great as it will have to bear in service by means of two bolts, which pass through the whole thickness of the sleeper, with heads underneath it, and whose upper ends, which protrude above the chairs, are secured by nuts.

The enormous numbers of sleepers required on the railways makes the question of their supply an important one. If there are 80 to 100 million sleepers in use on the railways of Great Britain, the effect of a small reduction in price, or increase in durability, might be considerable. In this country wooden sleepers are nearly always used, and there is no doubt that creosoted wooden sleepers combine in a high degree the qualities required for making a first-rate road—toughness, elasticity, and little tendency to shift their position. But wood is by no means the only material of which sleepers can be made. Iron or steel sleepers can be employed, and possibly some form of armoured concrete sleeper will be found to possess advantages. Iron sleepers, though not used to any appreciable extent in Great Britain, are widely employed in some parts of Europe, while in tropical countries they are often indispensable, owing to the attacks which insects make upon wooden sleepers. Metal sleepers are generally made somewhat in the form of an inverted trough. They are, of course, quite thin, and therefore, unless the metal is very tough, they are liable to crack. The friction against the ballast is very much less than that of wooden sleepers, so that they are much more liable to shift their position, and it is not nearly so simple a matter to fasten the rails to metal sleepers as to wooden ones. There are, therefore, considerable difficulties in the way of adopting metal sleepers, and there is certainly no immediate prospect of this being done on a large scale in this country. But it is always possible that circumstances might arise which would make metal sleepers so much cheaper than wooden ones, that there would be a great inducement to employ them.

A very good idea of the enormous magnitude of the work of keeping the railways supplied with sleepers is got by paying a visit to one of the places where the sleepers are received, stored, and prepared for use. The Great Western has a large establishment of this kind at Hayes, from which the eastern parts of the system are supplied, though there are several points where similar work is carried on for supplying the districts which are not within easy reach of Hayes. The Hayes establishment is immediately beside the main line, and lies on the bank of a canal by which the sleepers are brought to it on barges. On being unloaded from the barges, they are built up into long stacks, which gradually attain a height of some 40 feet beside the canal, and slope away to a height of some 20 feet or so on the landward side. The building of the stacks is facilitated by this slope, which enables the sleepers, as they are unloaded and hauled to the top of the pile beside the canal, to be lowered by gravity on the further side. A sort of wooden shoot, fitted with rollers, is used to help in this operation. It is laid on the top of a stack, anywhere it is wanted, and the sleepers are made to slide down it. The full capacity of the yard is about 300,000 sleepers, enough for about 140 miles of single line; they are left in the stacks to season for six months or more. The tops of the stacks are made accessible from the ground, without the use of ladders, by stairways made of sleepers, which are arranged to project some two feet from the stack. It is inadvisable for persons who are liable to suffer from giddiness to attempt to mount these stairways.

The sleepers, before being creosoted, are prepared in a machine tool of special construction, which planes the seatings for the chairs and bores holes right through the sleeper for the bolts, which are used in the latest Great Western practice. This is done before the sleeper is creosoted, in order to allow the creosote free access to the various incisions. The sleepers are now loaded on to trucks, which run along a narrow gauge line to the creosoting cylinder. Each cylinder is some 70 ft. long, and 6 ft. in diameter, and will hold about 300 sleepers at a time. When the sleepers have been run into the cylinder, the end is securely closed up, and the air in the cylinder exhausted by means of an air pump. When a high vacuum has thus been created, the creosote, which has previously been heated to a temperature of about 120 degrees F. to make it sufficiently liquid, is admitted into the cylinder from an adjoining tank, and a large quantity is at once absorbed by the sleepers. The amount thus absorbed is, however, not enough, and after the cylinder has been completely filled with creosote, a force pump is set to work, which, in the course of an hour or so, thoroughly soaks the sleepers with creosote till each has absorbed about $3\frac{1}{2}$ gallons, or 37 lbs. The force pump is then stopped, the unabsorbed creosote run back into its tank, a fresh vacuum created, which cleans off the surplus creosote from the outside of the sleepers, and the process of creosoting, which under these conditions costs, all told, about one shilling per sleeper, is complete. All that now remains to be done before the sleepers are ready to be sent out for use, is to take them to a shed, where the chairs are fastened on accurately to gauge. They are then loaded on to the peculiar long low four-wheeled trucks on which they are sent out wherever they are wanted.

At Hayes, besides the sleepers of ordinary wood, there were a small number made of various Australian hard woods, which require no creosoting, and, though considerably dearer than the ordinary kind, give promise of having so much longer a life as to make their use economical.

The rails, owing to the heavy moving loads, which are constantly passing over them, and to the strains due to the application of the brakes, are practically always creeping—*i.e.* very slowly moving along lengthwise in the direction of the traffic. This movement is very irregular in amount, but it is often necessary to readjust a line every few months. The readjustment is fortunately a fairly expeditious process. The keys are knocked away from three or four rail lengths at a time, the fishplates loosened, and the rails moved back to their proper places by a gang of some twenty-five platelayers, and made fast again in a few minutes. A more mysterious, and often more troublesome affection of the permanent way, is the tendency of the running surfaces of some rails not to wear away evenly, but to work into corrugations; these may easily become so pronounced as to make it necessary to replace an otherwise quite serviceable rail on account of the rough running which it causes. The noise, too, which is caused by corrugated rails, may be very objectionable, and in some places has been sufficiently annoying to people living in houses adjoining the railway to make it necessary to replace the rails for this reason alone. The corrugations, which generally occur at intervals of a few inches, appear most capriciously—sometimes all the rails for a considerable distance may be affected, sometimes only one here and there. And the reason of the appearance of the corrugations is most uncertain. Some engineers are convinced that it is due to faulty rolling of the rails—they surmise that the rail is allowed to get too cold before it is put through the last set of rolls, so that the surface becomes case-hardened, and is not homogeneous with the rest of the rail. The manufacturers probably do not concur in this view. Yet another trouble connected with the rails is that, under the stress of traffic, they tend to get bent permanently in a vertical plane—each length of rail gets higher in the middle than at the ends. This deformation proceeds very slowly, and, though it sometimes happens that it is necessary to take the rails out and straighten them, this is only done exceptionally. Deformation of this kind is sometimes sufficient to impart to the rolling stock a slight heaving motion, which is quite perceptible, at any rate upon the engine.

The provision of improved crossings is a matter to which some attention is now being paid. Under ordinary circumstances, wherever the path of one rail crosses that of another, space is left to give a passage to the flanges of the wheels, with the result that the bearing surface is not continuous, and the wheels are exposed to blows of considerable violence, which are not at all good for them, or for the vehicles which they support. The advantage of the ordinary system of crossings is that there are no movable parts, and therefore there is no necessity for setting the rails in one or other direction for the different trains. But, by introducing a certain number of movable parts it is possible to eliminate the vacant spaces, and, although this increases the complication, it is probably worth while to get rid of the heavy blows to the wheels, which ordinary crossings involve. An advantage of such an arrangement is that the paths of the rails at diamond crossings can be set at a much more acute angle to one another than can be done with safety at ordinary diamond crossings, where it is not permissible to have crossings flatter than 1 in 8.

To arrive at some conclusion as to the size of engine wanted to work a train of given weight at a given speed it is important to know, as nearly as possible, how much power is required to move rolling stock of different kinds along the rails at various speeds. As the permanent way has gradually become stiffer and stronger, and the rolling stock more flexible and smoother running, the trains have become easier to haul, so that the older formulæ for calculating the train resistance have passed completely out of date. Even when the types of permanent way and rolling stock are known, the problem is not susceptible of a really accurate solution owing to the very varying conditions which exist. On a level line, the resistances which have to be overcome in order to keep a train in motion, are principally those due to the friction in the axle bearings and of the wheels against the rails, to the air which the train displaces as it proceeds, and to the fact that the train, as it runs along, slightly depresses the line, in which process a considerable amount of energy is consumed. But many circumstances may modify these various resistances—differences in the strength and evenness of the permanent way, the kind of lubricant used in the axle-boxes, the direction of the wind, and so on. Nevertheless, attempts have been made to arrive at results which correspond nearly enough to average conditions to be used as a basis of calculation. Different investigators naturally are not in complete agreement with one another, but with good passenger rolling stock in good condition it may be assumed that the average pull needed to keep one ton moving at 30 miles an hour is 6 lbs.; at 60 miles an hour 15 lbs. are required, and, for speeds higher than this, the resistance increases by about 1 lb. for every 2 miles an hour. These resistances apply, of course, only to trains moving on the level. For trains running up or down hill, the effect of gravity has also to be taken into consideration, but this is always exactly proportional to the rise or fall of the line, and there is no difficulty in determining what it is in each case.

The South Western, alone among the big railways serving the Metropolis, has refrained from building itself a terminus north of the Thames, and it has thus avoided the necessity of making a big bridge across the river. In and around London, indeed, the South Western possesses few works of any architectural or engineering interest. Waterloo Station, in particular, has not, up to now, ranked as one of the principal glories of the Capital. With its narrow platforms, steep, inconvenient approaches, and cramped buildings, it has been more in keeping with its dingy surroundings, than worthy of its importance as the terminus of a great railway. It has, indeed, never been anything but a provisional structure, destined to endure only until convenient opportunities should arise for its gradual reconstruction. That reconstruction has now begun with the erection of the new South station, and clearances have been made on the north side, which will give more much-needed space, and pave the way for the very difficult and complicated work of entirely remodelling the rest of the old structure.

Waterloo Station was something of an after-thought, and, from the original terminus at Nine Elms, an elaborate and costly viaduct has been necessary, and the greatest economy of space has naturally been practised. But at Nine Elms the South Western has its operations much facilitated by the possession of a considerable area of ground, so much, indeed, that till quite lately the locomotive works were situated there.

Though the South Western is principally a passenger line, the fact that all its London goods traffic, instead of being divided up between a number of smaller stations, is dealt with at Nine Elms makes that a very busy place. Arrangements at goods stations are, like many other things, in the nature of a compromise between what is desirable and what is practicable. At Nine Elms the main goods sheds and yard lie between the viaduct carrying the main line to Waterloo, and a frequented roadway. On the other side of the road lies a wharf, and, as there is no difference in the levels, wagons have at intervals to be passed over the roadway itself on their way between the wharf and the goods station proper. Certain heavy and bulky goods, too, are dealt with on the further side of the viaduct, so the place is very much divided up, and certain natural difficulties are encountered in working it, as is often the case in London and other big towns, where land is valuable and difficult to secure, and the cost of remodelling is prohibitive. The original passenger terminus of the railway, Nine Elms, is even now not entirely delivered over to the goods traffic; it is still used for the military traffic to Aldershot and elsewhere, and it was from one of the platforms at Nine Elms that a great part of the British Army started on its journey to South Africa at the time of the war. But, though Nine Elms may occasionally relieve Waterloo of passenger traffic of special kinds, it is goods in never-ending streams that provide constant employment for the staff of some 400 men, which is attached to this station. At a big goods station like Nine Elms work goes on for practically the whole of the twenty-four hours, but it is during the night, from about 7.30 P.M. to 5 or 6 the following morning, that the greatest activity prevails. The South Western finds employment for about 500 horses in collecting from every part of London goods for despatch by rail, and, though the railway is always glad to receive goods as early as possible, it is not till about 7 P.M. that the steady stream of railway drays and vans, supplemented by those of public carriers and of private persons, begins to pour in at the gates and range itself along the platform, on to which the contents of these vehicles are unloaded preparatory to being loaded again into the trains, which leave at intervals throughout the night for all parts of the South Western system.

To anyone walking about the great despatching shed at Nine Elms, the extraordinarily retail character of the trade of the country is brought home, when the smallness of the average consignment is seen. In most cases what the local tradesman or distributor seems to do is to forward to London a list of his requirements, and, by return, receive all the things he wants, subdivided and marked in such a manner that he has very little left to do but hand them straight on to his customers. Under these circumstances the work of keeping correct lists of all the different consignments and of seeing that all get sent to their proper destinations—work on which the efficient conduct of the traffic is entirely dependent—becomes a matter of great complication, and, of course, adds immensely to the expense incurred by the railway. The greater part of this work is done, as the packages are unloaded from the drays, by men standing at desks ranged along the platform, who receive, check and weigh the consignments delivered, and pass them on, to be wheeled by porters to the wagons, in which they are to be packed and sent off; or, if no wagon for the right destination is at once available, to some place where they can easily be got at when wanted. Hydraulic cranes are installed at intervals to facilitate the handling of the bulkier objects; but the cranes are not much used, as few of the packages received are big enough to make this necessary. In order to ensure an expeditious beginning of the various operations which have to be carried out, the men who receive the goods are paid by the piece, and are able to earn higher wages than their comrades who are paid by the day; but that no unfairness should result from this arrangement, all the men employed, who belong to certain grades, are given a turn at this work one week in four. When the packages reach the wagons, in which they are to travel, further checking is necessary, and the invoices are drawn up, while the packers proceed with the work of firmly, yet tenderly, wedging the different packages together, so as to make the best use of the space at their disposal, and, at the same time, make it practically impossible for any package to break loose, or fall on to the line. This result is further ensured by the tarpaulin sheet, with which the wagon is covered before it starts off. That the weight-carrying capacity, at least, of the wagons is not fully utilised, is shown by the fact that at Nine Elms it is calculated that the average wagon-load is three tons, instead of the ten tons which each wagon is constructed to hold. But three tons a wagon is in reality a very good result, and much superior to the results shown in many other places.

The various lines of rails in the shed will accommodate something over 150 wagons at a time. These wagons, at three tons each, will hold a very respectable quantity of merchandise, but they are far from sufficient to receive all that offers at Nine Elms on a normal evening, and, as the night wears on, the old-fashioned shunting engines, which ply up and down in the yard outside, have a good deal of work to do in hauling out the strings of wagons which are already loaded, replacing them with empty ones, and carrying out such marshalling operations as are necessary to complete the different trains, and get the wagons for the different destinations in order, so that those which are to be dropped at any particular station, shall always be in the right position next the engine. In the course of the night three wagons, generally speaking, come in empty to each berth, and go away again full. Some of the wagons are for places such as Bath, to which the South Western does not appear to supply at all a good route. Now that there is no longer any competition with the Great Western, one wonders why arrangements are not made to send everything for Bath by that line. But sentiment plays a part in railway business, and there are firms who have always sent their wares by the South Western, and would feel that all their arrangements had been upset if they could no longer do so. And, as a difference in transit time of an hour or two during the night is of no importance, a wagon continues to be dispatched, when necessary, from Nine Elms to Bath.

In another shed, next to the one just described, are drawn up wagons, ready to receive such large consignments as come in. This shed is arranged so as to enable the drays to draw up on one side of a platform, at the most convenient spot for their contents to be loaded straight into a railway wagon, which is standing on the other side. In this way the goods require the least possible amount of handling, and are, of course, much easier to deal with than the miscellaneous collections of things for many different destinations, which are disposed of in the bigger shed, where, moreover, owing to the fact that there are several railway platforms, but only one roadway, it is in most cases necessary to move them some distance, between the time they are unloaded from the drays, and the time they are loaded again on to the railway wagons. Further on, again, where goods for Southampton Docks, and for the steamers serving the Channel Islands are sent off, some large consignments are handled. Half a wagon load, for instance, of cases of champagne, consigned to New York by way of Southampton, showed that the American tariff does not entirely prevent our railways from earning money by forwarding goods to the United States.

The different trains are sent off as far as possible in such order as will cause them to reach their destinations at convenient times in the morning. The Plymouth train, for instance, starts at 10.30 p.m., and, running probably as far as Exeter before it drops any wagons, reaches Plymouth at 6.30 a.m., while trains, which are to run only short distances, do not leave till perhaps 6 a.m.

All the traffic dealt with in the evening is outwards traffic, but, as the night passes, and the trains are sent off, space is gradually made for the incoming trains, which will begin to arrive early in the morning with supplies to be distributed throughout London before a great part of the world is awake. Owing to the careful order in which all these things will arrive, their reception will involve much less labour than the despatch of the outwards goods necessitates.

It is not surprising to learn that a good many men, among the large staff employed, are unable to find satisfactory dwellings in the immediate neighbourhood of their work; to overcome this difficulty, the men are encouraged to live in the outer suburbs. The encouragement is supplied by their being allowed by the company to travel to and from their work free of charge. This in itself must be accounted a very considerable advantage. But the men receive several other miscellaneous benefits from their connection with the Company. Up to their retirement, which, it is satisfactory to hear, is not compulsory at any particular age, but may be deferred so long as their health and strength endure, they receive pensions, to which they have not made any contribution, and there is a resident doctor, to whom they have access without payment. That many of them have a certain amount of money to spare is pretty clearly shown by the fact that there is a constant demand for the privilege tickets, which are issued to railway servants at a quarter fare, while at Bank Holiday times applications are received for many hundreds of such tickets.

At Clapham Junction, four miles from Waterloo, the main line is relieved of some of the suburban traffic, which branches off along the Windsor line. The volume of suburban traffic, which the main line has to accommodate, still remains considerable for some distance, but the existence of four lines of rail and of several flying junctions, helps to prevent delays, and otherwise the line is admirably laid out in a series of long gentle inclines all the way to Salisbury.

There are four lines of rail from London to the point where the Southampton line leaves the main line to the west, a few miles beyond Basingstoke. The capacity of a railway with four lines of rails is, under ordinary circumstances, much more than twice as great as that of a double line, because the pace of the trains varies a great deal, and, on a double line, it is impossible to arrange for a regular succession of trains at very short intervals of time. To get the greatest value out of a railway, the greatest possible tonnage must be passed over it in a given time, and, to do this, the ideal conditions are that each train should be as heavy as possible and should occupy as short a section as possible of the running lines for as short a space of time as possible, and that all the trains should be run at the same speed. The weight of a train is generally limited from considerations other than those for securing the greatest possible economy, but by increasing the number of block sections up to the manageable limit, the capacity of the lines may be proportionately increased. On underground and tube railways, where all the trains run at exactly the same speed, and the block sections are also very short, the capacity of each line becomes very great. To make the capacity of an ordinary double line as great as possible, the trains have to be arranged so that those of approximately the same speed follow one another—the expresses run at certain times and the goods trains at other times—but to draw up a really satisfactory scheme of working is of course very difficult. Where the traffic is very great, and two sets of double lines are laid, the working is much facilitated, as one pair of lines is used for the faster, and the other for the slower, traffic, with the result that all the trains running on either line are much more nearly of a pace than they would otherwise be. But on main lines, even when there are four lines of rails, it is not possible to do more than arrange that trains using the same lines shall run at approximately the same speed, and, in order to achieve even this, goods trains are frequently run faster than would otherwise be necessary.

Where trains are frequent one of the arrangements for obviating delays and increasing the safety of working, is the use of flying junctions. There are, as before remarked, several of these on the main line of the South Western. In the case of a main line where a branch line deviates to the right, for instance, a down train, running on to the branch line, has, at ordinary junctions, to cross over the up main line, which it blocks for up main line trains. If a flying junction is used, the branch line leaves the main line on the far side, and then gradually rises or falls till it can be led over or under the main lines, thereby rendering any suspension of traffic on the up main line unnecessary, and making collisions impossible. There are, too, other advantages afforded by flying junctions. Wherever a line diverges from another, which is straight, it is advantageous to make the curve which it describes as flat as possible, and to give the outer rail an adequate amount of super-elevation, so as to necessitate as small a reduction of speed as possible. In the case of ordinary double line junctions, with ordinary crossings, very strict limits are set to the maximum radius of the curve described by the line, which diverges from the straight, and then crosses the second straight line at an angle which must not be sharper than 1 in 8; and, to make matters worse, it is only beyond the crossing that any super-elevation at all is possible. Both of these difficulties are avoided in flying junctions.

Salisbury Station was the scene of one of the most remarkable accidents that has ever taken place. On June 30, 1906, the *New York* called at Plymouth and landed 43 passengers for London, who started off late the same night in a special train. This train ran without a stop to Templecombe, which was reached punctually. Here engines were changed, No. 421 came on, and the train started off again at 1.26 a.m., being timed to cover the remaining 112¼ miles to Waterloo in 115 minutes. A few minutes were lost on the steep gradients at the start, and partially regained on the favourable stretch of line descending towards Salisbury, where the speed seems to have risen to about 70 miles an hour—quite a normal speed with one of the most powerful express engines and a train which weighed only about 120 tons behind the tender. But just beyond Salisbury Station the line bends sharply to the left, and it had been most explicitly laid down in the instructions, issued by the railway company to the engine drivers, that speed must be greatly reduced to pass over this curve in safety. Whether the driver—a thoroughly experienced man—forgot for a moment where he was, or whether he was suddenly taken ill, will never now be known; steam had been shut off and the whistle sounded, but the brake was not applied; the train dashed through Salisbury Station at a speed which those who witnessed it recognised as fraught with disaster. At a point just beyond, where the line is on a curve with a radius of only 8 chains, the impetus was so tremendous that the left-hand side of the engine rose into the air, and the engine turned over on to her right side, crashing, as she fell, into a milk train, which happened to be passing on the adjoining line. The first four out of the five carriages, of which the express was composed, were almost completely destroyed, and 24 of the passengers and the driver and fireman were killed, and also two other railway servants. Both the engine men having lost their lives, it was impossible to do more than theorise as to how it happened that the train was allowed to rush to destruction in this manner. The speed at the point where the accident took place ought to have been not more than 30 miles an hour, and calculations which were afterwards made showed that a speed of about 67 miles an hour was necessary to overturn the engine in the way in which she was overturned. The accident was in every way noteworthy—when one takes place owing to a curve, it generally occurs through one of the wheels coming off the line, and it is doubtful whether more than quite a few other genuine cases of the actual overturning of an engine by centrifugal force have ever been known. The fact that no derailment, in the proper sense of the word, took place at all bears witness to the extraordinary way in which an engine with a flexible wheel-base—No. 421 is an 8-wheel four-coupled engine, with a leading bogie—running over a well-laid line, with a check rail, will keep the rails on a very sharp curve at high speeds.

The Salisbury-Exeter section of the South Western is one of the most difficult lines in England. Leaving Salisbury, the first 17 miles are an almost continuous ascent; in the next 17 miles are three descents and two ascents, all steep, and in places as much as 1 in 80; next, a few miles of comparative level brings the train to Yeovil Junction, 39 miles from Salisbury. After this there are three principal banks—4 miles at 1 in

150 immediately after leaving Yeovil Junction; 3 miles at 1 in 80 to a summit at post $133\frac{1}{4}$; and, worst of all, 7 miles from post $146\frac{1}{4}$ to the Honiton tunnel, of which the $4\frac{1}{2}$ miles from Seaton Junction are at 1 in 80, and the rest not much easier. The best time for the 88 miles is 96 minutes, which is just 55 miles an hour. This would be a respectable speed even over an easy line. If the difficulty of the line is taken into consideration, this timing between Salisbury and Exeter is the most remarkable in Great Britain. There is practically no level ground anywhere, the gradients both rising and falling are exceptionally steep, and nearly all the principal ascents are long enough greatly to reduce the speed of the train by the time it reaches their summits.

It is noteworthy that the best time for the $83\frac{3}{4}$ miles from Waterloo to Salisbury, where the line is far easier, is 91 minutes, which makes the average speed only the same as for the 96 minutes Salisbury-Exeter run.

Now that the Great Western's new main line to the West, via Westbury, has been opened, the distance to Exeter is almost the same by either route—the South Western has only about two miles the better of it. If a race were to take place the two companies should be very evenly matched, for, though the South Western gradients are the harder, there are on the Great Western route a greater number of curves which have to be traversed slowly. Exeter, however, in comparison with Plymouth, is a small place, and Plymouth is the objective of both lines. As the crow flies, Plymouth is less than 40 miles from Exeter, but exactly in between is the high-lying and practically uninhabited region of

Dartmoor, which could not be crossed and had to be avoided on one side or the other. The South Western line, striking first of all north-west from Exeter, and then due west, keeps to the western edge of the moor when at length it turns south. No amount of engineering skill could prevent a line through such country from being an exceptionally difficult one. A great deal of it is at 1 in 80, or a little worse, and, though the rising gradients are not absolutely continuous, the line climbs so steeply that a summit of 950 feet is reached near the great Meldon Viaduct, which spans the gorge descending from the foot of Yes Tor—the highest point in the West Country. From this summit there is a correspondingly steep descent to Plymouth, which is not reached till the train has travelled 59 miles from Exeter (Queen Street)—about half as far again as if the line thence were straight. The Great Western line, on its southerly course, does not make quite so wide a *détour*, and running along the coast for the first 20 miles, does not reach the hilly country till after Newton Abbot. But, owing to the extreme severity of the Great Western route from here onward, it is not impossible that, if the hypothetical race between the two lines were continued from Exeter to Plymouth, the Great Western's 52 miles from St. David's would take nearly as long as the South Western's 59 from Queen Street.

The summit of the South Western is not nearly the highest point reached by rail in Devonshire. The Great Western possesses a little branch line which strikes boldly out on to the moor to the great convict prisons at Princetown, some 1400 feet above the sea. There can be few remoter places reached by a railway than this veritable plague spot, which disfigures what would otherwise be one of the most romantic corners of England. From its junction with the Plymouth and Launceston line, the curious little railway winds steeply up the slopes bordering Dartmoor till, about mid-way, it emerges on to the open moor, and, by means of a series of the sharpest possible curves, continues to follow the contour of the country in such a manner that no works of any magnitude are made necessary, and then at last, crossing a ridge, arrives at its singularly unattractive destination. Considering the extreme meagreness of the traffic, Princetown may think itself well treated in the number of connections it has with the outside world. Six or seven times a day, in either direction, the tank engine, which works the line, may be seen hauling across the moor the solitary carriage, of which the train is usually composed.

There are not many countries in the world where a line of this kind would be protected in the complete manner in which this line is protected for the benefit of a few ponies, which pick up a scanty living on the moor. Elaborately fenced from end to end, and provided with over and under bridges at intervals, the Princetown line is as carefully enclosed as one of the great main lines.

Probably the most important step which the South Western ever took was the purchase, some 20 years ago, of Southampton Docks. From that time onward the Company has continuously developed the docks till, at the present time, it is putting the finishing touches to the last corners of its estate, and, for any further extensions, will have to seek space elsewhere. The area of the docks is roughly a triangle, with a base to landward of some half to three-quarters of a mile, and projecting about a mile out to sea. Southampton is one of the places where nature has been really kind. The first branch of the tidal wave reaches Southampton, via one side of the Isle of Wight, and is followed exactly 2 hours later by a second branch round the other side, with the result that there are two successive high tides at two-hour intervals—practically one continuous high tide for this period. The range of the tides is not very great, and the place, though land-locked and completely sheltered, is approached by a deep water channel. With all these advantages Southampton was a tempting place to develop, and certainly the railway has stinted neither money nor energy. Since the company took over the docks there has been a prodigious and rapid increase in the size of the biggest steamships, but Southampton, with all its natural advantages, has kept, and is keeping, well abreast of the requirements of these vessels. The *Olympic* herself lies easily in the new deep-water dock, and the Trafalgar dry dock has now been altered to take her in. At the time of my visit she was lying comfortably alongside in the deep water dock, where there are never less than 40 feet of water—a contrast indeed to the *Majestic*, which lay beside her, and had not so long ago been one of the biggest ships in the Atlantic trade. The reconstruction of the Trafalgar Dock, a work of some magnitude, included replacing the original gates, which opened outwards, and so could withstand pressure from the outside only, by a single sliding gate, which will withstand pressure from either side, and so makes it possible to have a higher level of water inside the dock than there is in the sea outside. The pumping engines, used for pumping the water out of this dock, are powerful enough to complete their work, if necessary, within 2 hours, but in practice the pumps do not work at their full power, as it is more convenient that the level of the water should sink gradually to enable the hulls of the ships to be got at for cleaning at leisure. Close by are some new shops, erected by Messrs. Harland & Wolff, conveniently situated for carrying out heavy repairs on the ships lying in the docks.

The most important part of the traffic dealt with at Southampton is the passenger and troop traffic, and, for the purposes of this traffic, the trains can be run into the various sheds, which extend along the water-side, and so get quite close to the berths at which the ships lie. These sheds are supplemented in some cases by covered gangways between shed and ship, so that the passengers are completely protected from the weather.

The greater part of the many acres of covered in space is composed of transit sheds, used for housing merchandise provisionally, till such time as it can be loaded on to the ships or into the trains in case it cannot be transferred direct from one to the other.

Southampton is chiefly concerned with high-class goods—manufactured articles of considerable value—and does not trouble itself much with such things as raw materials in bulk. There are, nevertheless, large storage warehouses for grain, and chilled meat, and various other things, which arrive in large quantities, and are warehoused till opportunities arise for their distribution. An important branch of the import trade of Southampton is the trade in chilled meat from the River Plate, for which a private company has a large storage warehouse several storeys high. The long rows of gloomy, windowless chambers, which compose this unattractive building, are kept at freezing point by an ammonia process worked from an adjoining engine-house.

Important adjuncts of the docks are the offices of the various British and foreign shipping companies, which run to Southampton, and also the South Western Hotel. The hotel people speak highly of the elaborate pains taken by the German agents to ensure the comfort of their passengers. The Germans, it appears, are so determined never to lose a customer through want of consideration on their own part, that, if one of their vessels is late in arriving, they will put the prospective passengers up at the hotel free of charge, while the provision of free meals for half a boat-load of people is a common occurrence. It is small wonder that the Germans succeed in business, when they work on these lines.

The question of the labour supply at docks is a difficult one. The work is of a nature so intermittent that a very large part of it must necessarily be performed by casual labour, upon the disadvantages of which it is not necessary to dwell. But, if the railway company cannot find continuous employment for the army of dockers who are constantly passing in and out of its service, there are various steps which it can take to secure to some extent their well-being. Chief among these is the provision of opportunities for securing proper food. The company has, therefore, built at various points about the docks dining-rooms for the use of the dockers. The dining-rooms are let out to contractors, but the railway company imposes strict conditions as to the prices that may be charged, and insists upon a good quality of provisions being supplied. There was certainly no doubt as to the popularity of one of the dining-rooms which I entered, nor as to the moderation of the prices—sixpence, for instance, for hot meat, three vegetables, bread and coffee. Another thing that is done for the dockers' comfort is to put down a flooring of wooden blocks, instead of concrete or other material, upon the quays where the work is done, because the wooden blocks are much easier for the men's feet.

The 51 berths and 6 dry docks at Southampton are not by any means exclusively used by great ocean liners. Private yachts from all parts frequently visit the docks. When I was there a beautiful yacht, belonging to an American millionaire, had just been taken into one of the smaller dry docks. His Majesty's ships are by no means strangers to the place, and here also is the starting-point of the South Western's cross-channel service to Havre. This service, which runs at night, offers in its own way great conveniences, which are perhaps not so widely appreciated as they ought to be. The steamers leave either Southampton or Havre at midnight, and give the passenger an uninterrupted 7 or 8 hours, which, if he happens to be a good sailor, or if the sea happens to be smooth, offers possibilities of an adequate night's rest. Those who have experienced the miseries involved in crossing by night from Calais to Dover will appreciate the advantages which the longer crossing gives.

The South Western was just putting a very interesting new boat into this service—the *Normannia*. This boat was the first to be fitted with geared turbines.

Turbines, unless they are of very large size, must revolve so quickly that they have to be fitted with very small screws. These screws, having so small a surface, do not grip the water, and so are not efficient for manœuvring purposes. In the *Normannia*, therefore, while the high-pressure turbines revolve at 2000, and the low-pressure at 1400 revolutions a minute, these turbines do not work direct on to the screws; the speed of revolution of the screws is reduced to 300 a minute by means of drums, which engage with each other through double helical gearing, and screws of the most desirable size can be used.

At Eastleigh, close to Southampton, are the locomotive, carriage and wagon works of the South Western. At intervals the different railway companies either remodel their works, or else move them to some completely new place, where more space is available, and each time this is done, an opportunity occurs for laying out the new or remodelled works in accordance with all the newest ideas. The South Western is the latest line to move its locomotive works. Only quite recently have they been removed from Nine Elms to Eastleigh, where, however, the carriage works have been situated for a good many years. The company, when deciding upon Eastleigh as the new site for its works, was evidently determined that there should be little danger of insufficiency of room at any future time, and therefore became possessed of a very considerable area of land in excess of what it so far requires. The designers of the new locomotive shops, having had plenty of space at their disposal, certainly did not stint themselves, and quite rose to the occasion in providing the clean, light and roomy buildings, in which the South Western locomotives are now constructed. In laying out new works, the great aim must be so to arrange the different shops that the materials are passed on from one to another by the shortest possible route, in order to simplify organisation and save labour. At Eastleigh, therefore, the pattern shop is between the iron and the brass foundries ; these latter are conveniently placed for handing on their products to the respective machine shops ; the machine shops in turn occupy the end and one side of a huge shed, of which the further side is the boiler shop, and the central bay the erecting shop. In this manner the erecting shop, where the finished locomotives are produced, is fed in the most convenient way from the shops all round it. The bewildering array of machines in the machine shops is driven by electrical power, as is now the common practice, and the electricity required is produced in a power-house adjoining these shops. As the present works are likely to be considerably extended and developed from time to time, the power-house has been made with plenty of spare room for increasing the size of the installation as time goes on. When the Eastleigh works were being laid out, the opportunity was taken of acquiring several machine tools of great power and capacity. The feats, indeed, which machine tools perform, grow constantly greater ; it seems to be only a question of money to make a tool of almost any capacity. In one place there is a machine that will plane ten or a dozen axle-boxes at a time, and, close by, another that will drill 24 holes simultaneously in a fire-box.

A boiler shop is never a pleasant place for any one who is not by long habit accustomed to the noise, but the general use of hydraulic rivetting machines for closing all the rivets, which these machines can reach, certainly tends to create a calmer atmosphere. In the boiler shop at Eastleigh may be seen several of the specialities of the South Western. Chief among these is the system of fitting water tubes across the fire-box. A large number of these tubes are arranged across the fire-box, with one end some inches higher than the other; this produces an intense circulation of water through the tubes and in the water spaces of the fire-box, while at the same time the tubes about double the fire-box heating surface. A further and most important advantage is that the water tubes form a barrier across the fire-box, against which strike the small pieces of incandescent fuel lifted from the fire by the draught, which are thus prevented from being sucked through the tubes and thrown up the chimney as sparks. Another object of interest is the superheater, which the South Western is adopting. It consists of a chamber traversed by a number of short tubes, each of which is concentric with one of the boiler flues. One of these chambers is fixed on either branch of the steam pipe in the smoke-box, and the steam passes through it on its way to the cylinders, and, in doing so, is heated up by the hot smoke-box gases. These gases, having already passed through the fire tubes of the boiler in the ordinary way, though still very hot, are not nearly so hot as is arranged for with most forms of superheater, nor is the heating surface of the steam chambers so great as the heating surface of most superheaters, so the effect produced upon the steam is much less. Indeed, what is sought is little more than to dry the steam thoroughly before it reaches the cylinders, and the advantages on the one hand, and the difficulties on the other of working with highly superheated steam do not come in. The economy achieved, however, has shown itself in practice to be very considerable.

The construction of the tenders fitted with the feed-water heating apparatus, can also be studied in the boiler shop. These tenders have a well, which is traversed by a number of pipes, through which part of the exhaust steam is turned. Water from the main tank above can enter the well only through a hole near the end remote from the engine, so the water, before it enters the pipe at the front end of the tender, which leads it to the pump, is thoroughly heated up. The engines with tenders of this design have no injectors, but their boilers are fed by pumps, which are worked independently of the main cylinders of the engine ; so they, like injectors, can be used whether the engine is standing or running.

Rather an interesting speciality of the South Western is the method of constructing the crank-axles of the locomotives. Until fairly recent times crank-axles were made all in one piece out of a large forging. The more modern practice is to use axles which are built up out of a number of separate pieces, all of which are of quite simple shape, and are easy to machine. The pieces which form the webs of the cranks are made with holes, which, at normal temperatures, are just too small to receive the horizontal pieces. To fix the different pieces together the webs are heated till the holes in them have increased in size enough to allow the horizontal pieces to be inserted, and when the webs have subsequently cooled, they hold the horizontal pieces in a firm grip, which is made firmer still by the insertion of rectangular steel keys into key-ways cut half in each of the two pieces which are to be consolidated. The South Western has introduced a refinement into the construction of the crank web. The balance weights necessary to make an engine run smoothly are generally put into the rims of the driving and coupled wheels. In the latest South Western engines, however, the disturbances, which originate in the interior mechanism of the engine, are balanced by large bosses, which are formed by extensions of the crank webs. The disturbances are thus balanced in very nearly the same plane as that in which they arise.

In the erecting shop I was lucky to find that the first of a new batch of 4–4–0 engines had just been put upon her wheels, and, though unpainted and unfinished in many ways, had reached a stage of construction quite sufficiently advanced to enable it to be seen how very handsome a machine she is. The bold outline of the late Mr. Drummond's 4–4–0 engines * and the great simplicity of their design can never fail to strike anyone except persons, if there be any such, who fail to perceive beauty or romance in any kind of machinery. Besides the water-tube fire-box, the superheater and other South Western specialities, it is not

* Owing, no doubt, to the fact that Mr. Drummond, the late chief mechanical engineer of the South Western, had previously occupied the positions of locomotive superintendent on the North British and Caledonian successively, many of the South Western engines much resemble the engines of the Scottish companies, and particularly is this the case with the 4–4–0 express types. In spite of the existence of bigger engines with 10 wheels, these very handsome and workmanlike machines are the standard express type of all three companies, and as the gradients of the main lines of these companies are the most difficult in Great Britain, they do between them a very large amount of hill climbing.

difficult to find further points of interest in the design of this engine. In 2-cylinder designs the nearer together the cylinders can be put, the more smoothly does an engine run, so in this machine the Walschaërts' valve-gear has been adopted, which, requiring, as it does, only 2 eccentrics between the cranks, instead of the usual four, allows the cylinders to be brought as close together as they will go. The slide bars are of Mr. Drummond's special design, which—instead of, as is usually the case, being supported at either end, while the middle (where the principal stress comes) has no direct support—are supported in the middle, just where strength is required. These slide bars and an unusually large number of other parts of the engine are made of cast-iron, which is cheap, and, as a rubbing surface, works with very little friction. Then, there are the piston valves, 10 inches in diameter, which provide the freest possible exhaust, and the coupling rods, 10 feet long, the extreme length ever attained in these parts of an engine, not to speak of other minor, but none the less interesting, details.

But at places like the Eastleigh locomotive shops there is so much to see that, in order to get in a visit to the carriage and wagon shops, it is necessary to hurry on, while a great deal that is of interest remains still unexplored. The carriages and wagons are built in the older part of the establishment, which is situated on the other side of the branch line to Portsmouth. The remarkable advance which has been made in the use of bogies for passenger stock, is nowhere better seen than here, where all new passenger stock is built to run on 2 four-wheel bogies of standard design. The much greater smoothness of motion of carriages supported on bogies than of those with 4 or 6 wheels is readily understood when the mechanism of the bogie is laid open. Besides the swivelling arrangements, an appliance known as a bolster is suspended from the bogie across the middle of the frame, with liberty to move a little from side to side. The bolster is a kind of oblong box containing springs which give a certain amount of elasticity between the bottom and the cover of the box, and it is upon the cover of the box that the weight of the carriage rests, and to it that the bogie pin is secured. The bogie being attached to the carriage it supports by the central pin only, it is an easy matter to complete the attachment, and the bogie can be erected complete, before it need be brought to the carriage to be secured to it. To avoid the necessity of lifting the carriage to receive the bogie, a very neat arrangement is in use. While the carriage is standing upon supports above one line of rails, a complete bogie is wheeled up upon the adjoining line on to a table worked by hydraulic power. The table, with the bogie on it, is then lowered into a pit, run sideways under the flooring until it is underneath the carriage, and then raised into position and secured.

The question of heating the carriages in cold weather is almost as difficult to solve as that of lighting them at night. In really cold countries it is generally found necessary to have a self-contained heating apparatus in each carriage; but in England, where the winters are comparatively mild, the carriages (where footwarmers are not in use) are usually heated by steam from the locomotive. This steam is led along a pipe running the whole length of the train, with branches in each compartment through which the flow of steam may be regulated. In some cases the heat is retained by means of reservoirs filled with some heat-retaining chemical, through which the steam is made to pass. A drawback of an apparatus which depends for its heat on the locomotive is that, if the driver finds that he has no steam to spare, he is not unlikely to restrict or entirely cut off the supply.

The machine shops in the carriage and wagon works are not less remarkable than those in the locomotive works. The sight of a machine making a screw complete in every detail, with hardly any supervision from the workman in charge, and of others performing not less curious feats, must always fascinate the non-expert. A good many things, some of more or less complicated shape, are now made simply and expeditiously by means of dies; the white-hot metal is put between the dies, hydraulic pressure is applied, and, when the rough edgings, where the metal has not entered the die, have been knocked off, the whole operation of manufacture is over. To do the same work by any other means would often be a long and difficult business. Things of shapes so irregular as drawhooks are satisfactorily produced by this means.

After the metal working shops, the saw-mill and paint shops are entered with a sense almost of relief. Metal working of any kind wants so much force that the men or the machines therein engaged always seem to be occupied in a stern and relentless struggle with a stubborn foe; very different is the impression created by the cheerful sound of the circular saw, as it buzzes through timber, or by the quietness and the clean smell of the paint shop. As I passed through this latter I asked a question which has always puzzled me—

"What are the colours which the South Western carriages are painted?"—and was somewhat amused to find that the South Western people themselves are unable to state what they are.

For the satisfactory working of a railway it is necessary to have efficient means of controlling the trains besides engines of sufficient power and suitable design for hauling them. The two principal factors in this control are the signals and the brakes.

The theory on which railway traffic is generally conducted is that every line is divided up into a number of lengths, upon each of which there is never more than one train at a time. This constitutes the so-called "block system." Each length is under the control of a signalman, who permits no train to enter it, unless it is unoccupied, and each signalman is in constant communication, by means of electrical instruments, with the signalman, who controls the length of line on either side of the length which he himself controls. There is thus a complete chain of control from end to end of the line. A train cannot start from the terminus till the signalman in charge of the starting signal has been informed by his colleague in the next box down the line that the previous train to leave the terminus has passed beyond that box, and the colleague in turn will not allow the train to proceed into the section, at the entrance of which he is stationed, till he has received similar information from the signal-box next beyond his own. So, at the beginning of every length, into which the line is divided, there is placed a signal, which can assume a horizontal or a slanting position instructing the engine driver respectively to stop or to proceed; and this signal is moved by the signalman in charge, in accordance with the information which he receives from up and down the line.

This is the general scheme for the control of the trains. In practice the arrangements are somewhat more complicated. In order to give the drivers adequate notice of the position in which they may expect to find the stop signal—which is known as the "home" signal—another signal, known as the "distant" signal, is placed some half-mile away from it, and this signal is never lowered unless the home signal is lowered also. A driver, therefore, who finds the distant signal in a position which allows him to proceed may go ahead with full confidence. If the distant signal is at danger he passes it, but prepares to pull up, if necessary, at the home signal. At stations and various other places there may be one or two more stop signals at intervals beyond the home signal—known as the "starting" and "advanced starting" signals. In this case the distant signal is not lowered unless all these stop signals are lowered also. On any section of the line where they exist it is of course possible to protect one train with each of them, and so more than one train at a time may be admitted to that section. On a double line, where all the trains run in the same direction, and there are no points or crossings, and the only danger that has to be guarded against is that of one train catching up another, it is quite a simple matter to keep the distance between them, but where there are points, and it is necessary to prevent the trains from meeting one another, the arrangements necessary to ensure safety become more complex. The signals and points are then connected together in such a way that no signal can be lowered to allow a train to proceed until all the corresponding points have been correctly set for its passage, and those on neighbouring lines so set that no vehicle can be turned from them on to the line over which the train is to pass.

For the proper working of the block system reliance may be placed either upon the combinations of the brains of the pairs of signalmen, whose consent is necessary before any signal may be lowered, or the safeguard thus provided may be supplemented by a mechanical device which makes it impossible for any signal to be lowered for a fresh train to proceed until the last train, which has passed that signal, has got under the protection of the next signal further on. The apparently greater protection conferred by the latter arrangement is reduced by its being necessary to provide means whereby the apparatus worked by the train itself may be put out of gear if it goes wrong and the signal gets stuck at "danger." Instances have been known of the signalman's forgetting that a train has passed and locked the signal at "danger," and, when in point of fact the signal was working properly, supposing that it had got stuck, and releasing it with the emergency key. Irregularities, however, are so very rare in either system of block working that both systems must be considered quite satisfactory in practice. Less perfect, as several recent accidents have shown, are the safeguards at stations, where one signalman sometimes has it in his power to admit by mistake more than one train at a time into a section.

The British system of signalling is probably the simplest and most complete of any now employed. Practically all the signalling on the running lines is done by means of only two patterns of signal—both semaphores—and the only difference between them is that the stop signals have square ends and the warning signals have fish-tail ends. The considerable variety of forms of signal found on some Continental railways is absent, and the indications are to that extent less confusing.

In most cases the signals are moved by human agency, but it is also possible to make use of various systems, whereby the movements are brought about by the trains themselves, and no signalmen are required. This is effected by means of electric currents, which pass along sections of the rails, and are short-circuited by passing trains. For this purpose the different sections are divided from one another at the required intervals, by insulated rail joints. Arrangements of this kind are quite suitable for those parts of the line which pass through open country, but at junctions and big stations it is of course impossible to dispense with signalmen. But here also much may be done, by the interposition of electric or pneumatic power, to lighten the signalmen's work, and so reduce the number of men whom it is necessary to employ. With ordinary mechanical transmissions the exertion of pulling over a lever in the signal box is considerable, and in large boxes, where a great many movements are made in a short time, a man's powers are limited by the actual physical exertion entailed upon him. Where electric or pneumatic power is used for doing the work of moving the points and signals, the little levers which set the power to work, can easily be moved with one finger, and any reasonable number can be arranged so close together that the signalman in charge need hardly move from his seat. His work then becomes more analogous to working a typewriter, and the hard bodily exertion of an ordinary signal cabin is absent.

On some parts of the South Western main line the low-pressure pneumatic system of working points and signals is in use. In the open country, where there are no points or crossings, the signals are entirely self-acting. They are normally held in the "line clear" position by compressed air from a main running alongside the line; when no train is in the section protected, the compressed air is admitted under a diaphragm, by the agency of an electric current. This current, under these circumstances, passes along the rails and completes the circuit in such a manner that a valve admitting compressed air under the diaphragm is held open. When a train enters the section, the current is short-circuited through the wheels and axles of the carriages, and no longer serves to hold the valve open. This has the effect of exhausting the air under the diaphragm, and the signal goes to "danger" by gravity.

Where there are points as well as signals to be worked, the power is supplied by compressed air, but it is set in motion by a signalman's pulling over levers very much in the ordinary way, though of course with much less effort. The levers in the signal-box can, in the first place, be shifted by the signalman for only a part of their full stroke; this partial movement admits compressed air at a very low pressure—about 7 lbs. per square inch—into a pipe, along which this compressed air reaches a valve situated close to the signal or points to be moved. The valve then opens a passage for another supply of compressed air—at about 15 lbs. a square inch this time—to enter the cylinder which works the points or signal. When the movement is complete this fact is notified to the signalman by the compressed air, which has brought it about, returning along a pipe of its own to the signal-box and completing the movement of the lever.* Only then can movements be effected of other levers, which are interlocked with the first lever. The levers and interlocking arrangements occupy quite a small space, and are therefore more convenient than the ordinary arrangement, and the point rods and signal wires are replaced by iron pipes, along which the compressed air passes; a number of moving parts are thus done away with. These are some advantages to set against the rather large number and intricacy of the pipes. But the greatest advantage of the arrangement is undoubtedly the relief from physical exertion which it affords the signalman, with the result that this relief to his body can hardly fail to increase the alertness of his mind. The amount of relief is realised when, at a place like Clapham Junction, one sees the points set, with practically no exertion at all, for a cross-over road over some half-dozen other lines.

Ordinary visual signals leave very little to be desired in broad daylight; they are slightly less perfect at night, when colour, and not shape has to be depended on †; but when, owing to fog or falling snow, neither shape nor colour can be distinguished, some method other than the ordinary has to be employed. The only

* It is not considered necessary to arrange for this indication to be given when the signal goes to "line clear." It is given to indicate that the signal has gone to "danger" or that the points have moved, and are securely fastened either way.

† Possibly something may be done by means of flashlight signals to differentiate signals by night.

one that has so far been brought into habitual use is the system of signalling by means of detonators. When a fog comes on men are stationed by the signal posts to watch the indications of the signal and warn the drivers if it is against them by placing on the rail detonators, which explode with a loud report when the engine passes over them. If rather rough and ready, this is a fairly effective method of control, and, though trains are frequently delayed when there is a fog, accidents are very rare. But there are great inconveniences connected with fog-signalling in this manner. Elaborate precautions have to be taken that there shall always be a sufficient staff of men available at short notice, and, when every care has been taken, the fog may come on so rapidly and unexpectedly that some time elapses before they can reach their posts. Then, standing out for hours in the fog is neither a healthy nor a pleasant occupation for the men, while the companies are put to considerable expense. Fogs are fortunately not common enough to make it worth while making very elaborate arrangements for coping with them. The most effective way of signalling in a fog is certainly by arranging that the position of each signal shall be repeated to the driver, as he approaches it, either by audible signals in the cab of the engine or by an indicator before his eyes. Owing to the expense of the necessary mechanism and the general sufficiency of the existing system of signalling, only a few isolated experiments have been made with appliances of this kind, though in some parts of the world the driver is warned, if he passes a distant signal at "danger" by the sounding of an alarm whistle in the cab.

The Great Western has, however, gone further than this, and for some years now has been experimenting with a system, whereby there are given to the driver in the cab audible and visible indications of the position of the distant signals, and on the short Fairford branch line the distant signals have been done away with altogether, and replaced by the cab-signalling apparatus. This apparatus consists of a box fixed to the side of the cab containing a whistle blown by steam, an electric bell and a window, in which is displayed either a blank surface, or the word "danger." It is a comparatively easy matter to arrange that, if the signal is at "danger," a warning should be given to the driver, but it is not sufficient if the signal is at "line clear" that no indication should be given—some definite indication must be given also when this is the case. In the Great Western apparatus, if a distant signal is at "danger," the whistle is blown and the word "danger" is at the same time displayed, while if the signal is at "line clear" the bell rings; and, in each case, the indications continue till the driver himself stops them. The indications are given from a ramp laid between the rails, which, as the engine passes over it, is struck by a shoe fixed under the engine. So long as the "danger" indication has to be given, an electric circuit on the engine is interrupted when the shoe strikes the ramp, and this interruption sets the whistle blowing and causes the word "danger" to be displayed. When, however, the "line clear" indication has to be given, an electric current is passed through the ramp, the effect of which, as the shoe strikes the ramp, is to neutralise the interruption of the circuit on the engine and furthermore to set the bell ringing.

It is possible to carry the matter a step further, and cause the brake to be applied automatically if a signal is passed at "danger," but there are objections to this course. To apply the brake with the proper strength, according to the speed of the train, is, for one thing, a matter of fine judgment, which an automatic machine would certainly not be capable of exercising. A train travelling at high speed wants a considerable space to stop in, and, as it must be stopped before it reaches the home signal, the ramp which applied the brake would have to be situated far enough from the home signal to stop the fastest train before it got there, and this would, therefore, involve a violent application of the brake on slower trains long before it was necessary to put the brake on at all.

At some signal-boxes where rail circuits are in use there are plans of the lines controlled, on which the actual position of each train at any moment is shown by means of discs, which can turn red or white. If a train is on any particular rail-circuit, the discs corresponding to the beginning and end of this circuit are red—otherwise they are white. This device is very useful for locating trains in foggy weather.

The British signalling system, worked, as it is, by highly trained men, offers a high degree of security, and it is seldom indeed that, through any fault of the engine men, the indications of the signals are not given effect to. For ensuring the trustworthiness and experience of the drivers and firemen it would be difficult to imagine a more thorough training than these men are obliged to undergo before the lives of the passengers are given over into their keeping. As a rule, they enter the service of the railway company as boys, and spend some years in the running sheds, cleaning the engines which come in dirty from their work. This makes them familiar with every part of the engine, and, at the same time, they have opportunities of observing the fitters and boiler-makers carrying out any repairs which may be necessary, and they are brought into close contact with the drivers and firemen actually in charge of the engines, from whose experience they are able to some extent to profit. After some years the cleaners are promoted, as vacancies occur, to be firemen, first on shunting engines, and then, progressively, on engines engaged on more and more important work, till eventually they attain to the express passenger engines. All this time they are gradually getting better and better acquainted with the lines, over which they will have to work as drivers, so that, when they are eventually promoted to that rank, many years' experience of travelling over the railway has fixed in their minds the position of every signal and every other detail which they must know so as to work their engines with safety and efficiency. Besides this, they are from time to time examined by a doctor to ensure that their health is good, and their eyesight and hearing are also carefully tested at intervals. The eyesight test generally consists of counting, with either eye, varying numbers of black dots a fifth of an inch square on a white ground, which are displayed at a distance of 15 feet, and there are further tests for ensuring that the men possess good colour vision.

On single lines the problem of ensuring the safety of the trains is in some ways different from the problem which presents itself where the line is double. Measures must be taken not only for preventing one train from catching up another, but for preventing trains, which are travelling in opposite directions, from meeting. The simplest means of attaining this result is to allow only one engine at a time to be upon any given line, and in the case of very small branch lines it is sometimes possible to arrange that this shall be the case. But when one engine does not suffice, arrangements have to be made for the same principle to be extended in such a way that the line is divided up into a number of sections, upon each of which only one train can be at the same time, whether it is travelling in one direction or the other. This can obviously be brought about by not allowing any engine to enter any particular section, unless the driver is in possession of some token, generally a staff or tablet, of which only one exists. And this is the principle that is adopted. As, however, it is sometimes necessary to despatch more than one train in the same direction successively, a single token is not sufficient, so, while maintaining the principle, certain modifications have to be made in practice. The difficulty is met in various ways. One solution of the problem has been evolved, which is very complete. A considerable number of tokens are provided, the possession of any one of which gives a driver the right to proceed on to the section to which it has reference. There are, at the stations at each end of the sections, holders, to either of which any number of the tokens can be secured, and these holders are connected together electrically, in such a way that no token can be removed from either end, unless the whole of the tokens are at that moment in one or other of the holders, and only one token can be removed at a time; no fresh token, therefore, can be removed from either end till the one which is out has been returned to one holder or the other.

When a train passes the end of a single line section without stopping, there is a certain amount of difficulty in dropping the token which gives the right to pass over the section just traversed, and picking up another for the section ahead. Tablets attached to iron loops are sometimes used, and the firemen and porters become so expert at passing their arms through the loops and catching the tablets upon the shoulder while the train is travelling at something like 40 miles an hour, that very little time is lost in slowing down. A more perfect apparatus is used in some places, for which the tablets to be exchanged are enclosed in leather pouches, which are hung to the engine, and to a standard close beside the line, and one tablet is dropped and another picked up simultaneously, by means of appropriate catches, without any reduction of speed.

The signals are the means of conveying instructions to the driver, but when he has his instructions he must also have means at his disposal for carrying them out, and bringing his train to a stand at short notice, if necessary. The difficulty of doing this increases much more then in proportion to the speed at which the train is running, and very rapidly acting and powerful brakes are an absolute necessity for ensuring the safety of trains that are at all fast. The adoption of continuous brakes, more than any one other thing, has made high speeds possible, and instead of the trains being brought wearily to a stand by hand brakes on the engine and guard's van, as was formerly the case, the driver now, by a motion of his hand, puts on the brakes as gently or as hard as he likes, from end to end of the train. Of all the numerous systems of continuous brake evolved by inventors, the Westinghouse and the automatic vacuum alone are used in Great Britain. They both depend for their working on a pipe, which stretches from the engine to the last vehicle of the train. In the case of the Westinghouse brake the pipe is filled from an air-pump on the engine, with compressed air at a high pressure, and the brake is applied by reducing this pressure, so that if the couplings break and the train divides, the compressed air is liberated and the brake goes on automatically. In the case of the automatic vacuum brake there is normally in the train pipe a vacuum, which is produced by an ejector on the engine, and the brake is applied by reducing or destroying the vacuum. In this case also, therefore, the rupture of the couplings has the effect of applying the brake.

In Great Britain there are few descents long, steep, and curved enough to offer any serious difficulties, but in some parts of the world, notably in the Alps and Rocky Mountains, the speed has to be kept so low for so long together that special measures have to be taken to ensure safety. The difficulty arises from the fact that ordinary continuous brakes, after having been applied for some time, have a tendency to leak off, and have to be released, preparatory to being applied afresh. This operation takes an appreciable time to carry out, particularly if the train is a very long one, and during this interval, if the brakes were taken off altogether, the train might get out of control. So supplementary devices of different kinds have to be employed. In America the exhaust from the brake cylinder of the Westinghouse brake is fitted with a "retaining valve," which can be put into or out of operation as required. When in operation it acts in the same way as a safety valve, and, when otherwise the brake would be released altogether, allows only so much compressed air to escape from the brake cylinder as will still leave in the cylinder a pressure of 10 or 15 lbs. a square inch.

The biggest South Western and Caledonian engines have bogie tenders because, owing to the absence of water troughs on these lines, a large load of water has to be carried, and a few other bogie tenders have from time to time been built for various other lines, but in Great Britain the great majority of tenders run on 6 wheels. Now that most of the railways have put down water troughs, the weight of the tenders need not exceed what can be carried on 3 axles, and as the shortness of the wheel base of a tender allows it to round curves quite easily, without being carried on bogies, there is no particular object in using bogies—the 6-wheel arrangement has indeed some advantages, as it enables the lateral stability of the tender to be secured more easily, and this is a matter of some importance in a vehicle carrying a big load of water, which may, under certain circumstances, surge from side to side.

Where it is possible to make frequent stops for water, the use of tank engines makes it unnecessary to have tenders at all, and, as it is just on services of this nature that the engines most often change their direction, tank engines, which run equally well in either direction, possess great advantages. Lately, on certain lines like the Great Western, the use of tank engines has been extended, and some big engines of this type have been built, which are capable of performing fairly long runs with express trains. Where water troughs exist at sufficiently frequent intervals there is little to prevent a tank engine from performing runs as long as are performed by engines with tenders, but the troughs are not as a rule close enough together to enable tank engines to undertake very long runs. The height from the rail of the spring-borne portion of the engine must not vary more than a very little, as the machinery has to be arranged to work at one height, and any considerable deviation therefrom would have very serious ill-effects. As any difference in weight, such as there would be between an engine with her tanks and bunker empty and the same engine with her tanks and bunker full, has the effect of raising and lowering the height of the spring-borne portion, this difference must be confined within narrow limits, and so the tanks must not be too big; moreover, the engines which work the principal expresses are already about as heavy as is desirable, so, if they had also to carry 15 or 20 tons of coal and water, it would be necessary to provide them with at least one more pair of wheels which would greatly increase their cost and the difficulty of designing them. It is, therefore, not at all likely that tank engines will ever be much used for working express trains, though the performances of the big Brighton tank engines on the "Southern Belle" have shown that, under certain circumstances, they are capable of doing so.

CHAPTER V

THE RAILWAYS TO THE SOUTH AND EAST

Brighton Railway—Electric Railway Working—The Engines of the Brighton Railway—South Eastern Railway—Continental Services—Railway Finance—Great Eastern Railway—Local Taxation—Punctuality—Oil Fuel—Future of Railways.

THE problem of working the traffic in and out of London on a line like the London, Brighton, and South Coast Railway, or the South Eastern and Chatham Railway is one of great complication as compared with that on one of the big lines to the north.

The southern lines have a very large short-distance passenger traffic, as all the country lying to the south-east, south, and south-west of London is full of people who have constantly to be in and out of town; and the railways, which serve these districts, require the most ample facilities for getting large numbers of people to various convenient points in London. The South Eastern, possessing no less than four termini just north of the Thames, is in this respect almost ideally situated. The Brighton, with its termini at Victoria and London Bridge, is in the next strongest position.

The Brighton Railway serves a long stretch of the south coast, and possesses two main lines thither from London—one running due south to Brighton, and the other in a more westerly direction, through Dorking and Horsham, to Ford Junction, where it joins the line which stretches along the coast from Hastings in the east to Portsmouth in the west. Besides the long-distance trains, both of these lines have, for 30 miles or so out of London, to accommodate an exceptionally large volume of traffic from intermediate stations, and yet another line, joining the line from Brighton at Croydon, and used jointly with the South Eastern, brings a great deal more of this kind of traffic to London. A large proportion of all these trains convey passengers direct to both of the company's London termini, and this makes it necessary to divide them at East Croydon or Sutton. Added to all this the company possesses a whole network of lines in the London area, also connecting with both Victoria and London Bridge. The difficulty, therefore, of fitting in all the different kinds of trains upon all the different lines is obviously very great.

London Bridge, though it has the disadvantage of being situated south of the Thames, is in a fairly convenient position for people going to the City, and the rebuilt Victoria is certainly the most spaciously built and conveniently placed station in London. The reconstruction of Victoria was part only of a very ambitious scheme of widenings, which was to embrace the whole of the main line to Brighton, and is not yet complete. As time passed this main line had become more and more crowded with traffic, and the difficulties of working it had increased correspondingly. This was particularly felt on the section between Croydon and Redhill, where one pair of lines had to suffice not only for the Brighton trains to and from Victoria and London Bridge, but also for a large number of stopping trains belonging to the South Eastern, to which railway a section of the line actually belongs. Here relief had first of all to be provided, and in 1900 a new double line was opened by the Brighton Company. As far as Stoat's Nest, some three or four miles, it runs beside the old line, then diverges to the west, crosses over the old line a little before the Merstham Tunnel and rejoins it just before Earlswood. I got some idea of the enormous advantage conferred by this line on the Brighton Company, when, shortly after it was opened, an express train, in which I was travelling, ran past, and got in front of, no less than three trains which were running along the old line. After this widening was finished other sections of the main line were successively taken in hand, and four lines now extend all the way from Victoria to the north end of the Balcombe tunnel, about 32 miles. Meanwhile, the reconstruction of Victoria Station was begun, and, after it had been steadily proceeded with for a number of years, the present station was brought into existence. The works included the demolition of a long line of houses, the alteration of the level of several hundred yards of street, and the building of a large wing of the Grosvenor Hotel. However fast the traffic grows, this huge station should be sufficient to accommodate it for any period, to which the company can reasonably look forward. The chief point that strikes the observer is its great length—the platforms are something like a quarter of a mile long. This arrangement was necessary, as it was impossible to widen the station towards the south where the South Eastern terminus already stood, and only quite a narrow strip of land was available on the north towards

Buckingham Palace Road. The platforms are, therefore, arranged in such a manner that two trains can be drawn up, one behind the other at each. Specially convenient features of the new station are the large circulating area round the booking offices and waiting rooms, and the wide platforms, which give a feeling of spaciousness, unfortunately too often lacking in London termini. When it is remembered that the old station was bit by bit swept away, and the new one, in which no trace of the old one can be detected, put in its place, without a day's suspension of the traffic, it must be recognised that the engineers performed a very considerable feat.

In Brighton the Brighton Railway possesses in some respects the most favourably situated sea-side town in the world. The main line runs in practically a straight line from London to Brighton. It is well suited for fast running—it is admirably laid, it has fairly easy gradients, and, except in the London area, there are no curves, where speed has to be seriously reduced. The possibilities of traffic between London and Brighton are, therefore, immense. But, owing probably to the crowded state of the line and the great consideration which has to be given to the valuable suburban and semi-suburban traffic conducted along it, which make it a matter of some difficulty to fit in trains running very much faster than the average, the company has never made any attempt to develop the London-Brighton traffic to anything like the point which the very favourable position of Brighton renders possible. There is no disguising the fact that for a very long time the trains between London and Brighton were slow. Up to quite a short time ago the best up train took 70 minutes and the best down train 65 minutes (except on Sundays, when there was a train in either direction in an hour). Lately one-hour trains in each direction began to run on week days, and have now been multiplied till there are a fair number of them each way, but better things are required. If the company intends to make full use of Brighton it will have to put on a frequent service of really fast trains in both directions, which, now that the line to Brighton has been quadrupled to the very edge of the suburban area, should present no insuperable difficulties.

The London-Brighton service has been compared by many writers with the celebrated service in the United States between Philadelphia and Atlantic City, and the comparison is instructive. I do not know what the present timings of these American trains are, but for many summers the Pennsylvania Railway used to cover the 58¼ miles from its Camden Station to Atlantic City in 52 minutes, start to stop, and the rival Philadelphia and Reading trains were allowed 50 minutes for their 55½ miles, also start-to-stop. I am not acquainted with the line of the latter company, but on the Pennsylvania line the trains lost at least a minute at either end of the run owing to speed restrictions. One day, when I travelled with one of these trains, the middle 52 miles, where there are no slacks, were covered in 40 mins. 48 secs. The Brighton line is not, on the whole, more difficult than the Pennsylvania, so it is certainly possible to run between London and Brighton in 45 minutes, and, if it pays the American railways to run these trains for the benefit of Philadelphia, how much more should it pay the British company to run equally fast trains for the benefit of London, which has four times the population of Philadelphia. At present people coming up to London from Brighton for the day, or going down to Brighton from London, cannot do the double journey in less than 2 hours. This is probably just long enough to deter them from travelling very frequently. If the double journey could be done in an hour and a half a new set of conditions would arise, and Brighton, from being a provincial town, would become practically a suburb of London.

The very favourable position of Brighton in relation to London has not escaped the eye of the financier, and at intervals schemes for the construction of new railways from London to Brighton are launched, the object generally being to enable the journey to be performed in a much shorter time than is possible by the Brighton Railway. To judge from the failure in the past of any of these schemes to rouse the Brighton Railway into activity, none of them can have been considered by the company at all likely to come to anything; and all these attacks having been beaten off, it certainly seems unlikely that a rival line will ever now make its way to Brighton. But it is to be hoped that the company, secure as it is from competition, will not allow its newly acquired spirit of enterprise to evaporate before it has rendered its position securer still by the introduction of the really rapid service which the situation demands, and for which its customers have already waited all too long.

As regards the services to the other big places on the line besides Brighton, they are in most cases only moderately good. Portsmouth is probably the next most important place on the system, but, as the South Western possesses a much shorter route thither, the credit or otherwise of the Portsmouth service attaches primarily to that company. In the same manner the Hastings service is primarily the responsibility of the South Eastern. But Eastbourne depends on the Brighton company as completely as does Brighton itself, and, though some quite convenient trains run between London and Eastbourne, several of which have just been quickened by 5 minutes, the average speed of under 47 miles an hour, at which the best of these trains run, is unduly low, even when the existence of some very nasty curves—particularly those at Lewes—is allowed for. Lewes must be nearly, if not quite, the most awkward station in England. The main line from London approaches on a falling gradient, and through a tunnel, at the end of which it turns abruptly into the station by the sharpest possible curve, and continues on curves of small radius for some distance beyond; and, to make matters worse, there is at the further end of the station a most complicated system of points and crossings, where lines run in from Brighton on the one side and from the East Sussex district on the other.

If the Brighton Railway possesses a district very rich in passengers, it has not secured this district for nothing. There are few lines where the natural obstacles are so continuous. In the 51 miles between Victoria and Brighton, the ridges and depressions all lie across the path of the line, and the works include the bridge over the Thames at Grosvenor Road, a considerable viaduct, and some half-dozen tunnels—two of them more than a mile long. The great expense is probably the chief reason why this line was not earlier widened, and, even now, the widenings have only proceeded as far as the point after which the natural obstacles become the most severe and continuous.

With the widening of the main line and the rebuilding of Victoria Station, the Brighton Railway's reforming energies were not exhausted. For many years the railway companies have been complaining that the short-distance traffic was being filched from them by tramways, which, passing people's very doors at short intervals of time, have offered attractions with which railways could not compete, and in many cases, being subsidised by the rates, have demanded excessively low fares. For very short-distance traffic it is improbable that the railways will ever be able to recover the ground which they have lost to the tramways; but the tramcars, running as they do through the streets, can never attain any very great speed, and, though this is a matter of minor importance for very short-distance traffic, the Brighton company thought that for distances over about a couple of miles it might be possible, by introducing electric working, to provide a service so much superior to that of the tramcars in point of speed that there would be a very good chance of competing with the tramways successfully. The Brighton company possesses a line, nine miles long, beginning at Victoria, running through South London, and finishing up at London Bridge, which is peculiarly exposed to tramway competition, and a beginning was made by the electrification of this line. When it was worked by steam locomotives, the nine miles, in which there are the same number of intermediate stations, took some 35 minutes to cover. Owing to the much greater rapidity with which the electric trains can get away from the stations, the journey now takes only about two-thirds of the time which it used to take.

The installation of electricity on a line of this sort is something of an experiment. Here the conditions are not the same as those which are found in the tubes. Except on the score of inability to start very quickly, there is no particular objection to steam locomotives on a line of this kind in the open air. Though, in respect of rapid starting, electric working will always have some advantage over steam working, it would have been possible to build steam locomotives which, with the light trains required, could start very much more quickly than the steam locomotives which were used were in the habit of doing. Six-coupled engines with three high-pressure cylinders would not waste much time getting into speed, unless the trains were much heavier than those running between London Bridge and Victoria, and the expense of building eight or ten such engines could hardly have been anything approaching that which was involved in arranging the line for electric working. If electricity is in this case to gain a victory over steam, its working costs must be much smaller than those of steam. It is to be hoped that this will prove to be the case.

The Brighton Company, at any rate, seems to be particularly well satisfied with the electric working, for, very shortly indeed after it had been put into operation on the South London line, large and elaborate extensions to the Crystal Palace and over other lines in the suburban area were put in hand.

Most of us grew up so much accustomed to the steam locomotive that we had some difficulty in reconciling ourselves to the idea of an electric locomotive, and the first electric train we saw without an engine at all looked like a conjuring trick. When the possibility of using electricity as a motive power on railways was realised, many people had a strong, though ill-defined, feeling that this new and mysterious power would in a short time sweep away the antiquated steam locomotive, and make all railway things new. This view seems to have been held also by the more enthusiastic of the electrical engineers. The years which have passed by have served to fix our ideas. That a revolution has come to pass, and a very great one too, is certain. Almost every part of London can now quickly and cheaply be reached from almost every other part by trains running in tubes deep down in the bowels of the earth, and this is due entirely to the electricity that neither exhausts nor fouls the air, and makes possible the very rapid succession of trains, which distinguishes the new deep level lines. But for all the revolution has been a striking one, it has been partial only, and the limits set to the use of electricity on railways are becoming apparent. For all urban and suburban services, where the trains follow one another at short intervals, and stops are frequent, it is of a certain value, owing to the fact that as many of the axles of a train as required—all if necessary—can be made driving axles, so that a very large weight can be used for adhesion and speed gathered very rapidly from rest. Its use, too, in long tunnels on steep gradients, where the ventilation is defective, may obviate the use of very expensive blowing engines, without which the air of the tunnel would so quickly become exhausted by the combustion in the fire-boxes of steam locomotives as to make it dangerous to life and incapable of supplying oxygen to the fires. In some parts of the world tunnels worked by steam locomotives, particularly if they are single line tunnels, have an atmosphere so bad that, as the locomotive plunges into them, the lungs of any one on the footplate feel as if they were being filled with hot particles of sand. But that electricity has much of a field before it for working long-distance main line traffic does not so far seem to be the case, as here the advantages, which the use of electricity offers, are of no particular value. It is not a matter of much importance whether a train running 50 miles without a stop takes 2 minutes or 4 minutes to attain full speed. Electricity before it displaces steam for main line traffic will have to show some considerable advantage in cost, and, when the electricity is generated by means of steam engines it is obvious that the advantage in this respect is not likely to be very great. In this connection it may be noted that the Brighton Railway has so far most carefully avoided making public the cost of its electric services. In countries where a great deal of water-power is available, it is different, and in Sweden and Switzerland, for instance, electricity, having the advantage of greater cheapness, will no doubt be much used. But that it will displace steam on British main lines seems improbable, until some means are found for generating it much more cheaply than can now be done in a steam power-station. The tides, the winds, improved gas-engines, all offer possibilities in this direction, but there is no immediate prospect of the realisation of these possibilities. Meanwhile, for long-distance work, the steam locomotive fulfils with ease every requirement of the case, is certainly capable of doing much more than is now demanded of it, and possesses, too, the enormous advantage of being self-contained. The breakdown of one steam locomotive does not involve the breakdown of another, but, with electricity, any failure of the supply may stop the traffic of a whole district.

In derogation of the steam locomotive it is not infrequently asserted that, beyond compounding and superheating, no improvement in principle has been made from the days of Stephenson, to the present time. Though this is no doubt approximately true in the narrowest sense, a more misleading statement could hardly be made. Since that time the design and workmanship of practically every detail have been enormously improved, while the increases in size and power that have taken place are so great as to put the modern engine and her ancient prototype in the relative positions of the largest horse and the most diminutive donkey. What is perhaps the greatest advance in steam engineering practice that has ever been made—the replacement of reciprocating machinery by the turbine—can, unfortunately, hardly be applied directly to the driving wheels of locomotives, though various engines have from time to time been built to combine the advantages of steam and electricity, and in one of them the electricity used for driving the wheels was first of all generated by means of a steam turbine. For an arrangement of this kind to be successful the combined loss of efficiency of steam engine and electric motor would have to be so much less than the loss in an ordinary locomotive as to compensate for the additional expense involved in the building and upkeep of two sets of machinery instead of one.

The Brighton Railway is said to be about to consider a scheme for extending the electrification of its lines so as to embrace the main line to Brighton. As before remarked, the desirability or otherwise of such a course is entirely a question of cost. Apart from the question of cost, electricity offers for ordinary main line working no appreciable advantage over steam. The carrying out of such a scheme must partake very much of the nature of a step in the dark. It would be an interesting step, and, if from no other motive than curiosity, it is to be hoped that it will be taken.

Besides electricity, another possible rival of the steam locomotive has lately sprung up in the Diesel engine, an internal combustion engine, which works with crude oil. This engine, which returns in the shape of useful work a far larger percentage of the power which it receives than a steam engine could ever do, has lately come rapidly into favour, and there is no doubt that extensive experiments with locomotives constructed on this principle will be made.

It is fair to remark that when and if the steam locomotive is superseded by other modes of traction there can hardly be a doubt that railways will appeal much less than is now the case to the non-technical public. Probably the steam locomotive has at least as strong a hold upon the imagination of at least as large a proportion of the population as had the horse before the advent of railways. There is so much about the steam locomotive which suggests life. Fire, steam, smoke, the deep rhythmical beat of the exhaust, all help enormously in making that powerful appeal to the imagination which the steam locomotive addresses to so many people. The mere fact that the steam locomotive is not covered in has been an enormous advantage in stimulating general interest. Every part can be studied almost as easily as the points of a horse, and the gradual growth and development of the locomotive can readily be discerned and their causes understood by people who have had no technical training. The internal combustion engine, or the electric locomotive, can never be much more to look at than boxes on wheels, and, although probably not less interesting than the steam locomotive to engineers, who understand all about them, must be hopelessly left behind as regards the strength of the appeal which they make to popular imagination; and though it is neither possible to estimate the pecuniary value of sentiment, nor desirable to attempt to do so, the railways could hardly fail to be heavy losers if the appeal to sentiment which they make were to be greatly weakened. For myself, I must confess that I am one of that large company of people who find in the steam locomotive an object to which attaches a very high degree of romance. I know few more thrilling sensations than to stand on the footplate of an express engine which is rushing along at 70 miles an hour through the sleeping country, with the dawn just beginning to appear, while the dusky forms of the driver and fireman and the great cloud of white steam, as it rolls away overhead, are lit up from time to time by the glare from the furnace when the door is opened for a fresh charge of fuel.

One of the greatest names among the designers of locomotives in the past is that of William Stroudley, for many years locomotive superintendent of the Brighton Railway. His fame does not rest upon any particularly startling achievements of his engines. Little opportunity was ever given them to distinguish themselves by such means. Nor were any very important new inventions made by Mr. Stroudley, but the striking originality of his designs, their great everyday efficiency, the masterly way in which all the details were worked out, and his firm grasp of the importance of reducing the number of types of engines employed, and of making as many as possible of the parts of the different types the same, made a deep impression upon the subsequent development of locomotive practice.

The outstanding feature of interest in Mr. Stroudley's designs was his wholesale adoption of the four-wheels-coupled-in-front arrangement. This arrangement possesses almost every possible advantage, if it is desired to construct an engine of moderate weight, of great power in comparison with her weight, and a smooth runner. Front-coupled tank engines are, of course, used now to a considerable extent, but for express passenger trains other designers have always held that the leading pair (if not two pairs) of wheels have quite enough to do to lead, and no designer has ever before or since ventured to use leading coupled wheels for express engines, being apparently afraid that, even if they did not leave the rails, they would do some damage to the permanent way. But Mr. Stroudley had no fears on the score of the front-coupled wheels, and it is by his express engines of the "Gladstone" class—6-wheel engines with four coupled leading wheels, 6 ft. 6 ins. in diameter, and a small pair of carrying wheels under the footplate—that he will be remembered more than by any others; if confidence has ever been justified his has been by the record of these admirable locomotives, which, even now, more than 30 years after the appearance of the type, are capable of dealing with the best trains on the Brighton Railway, and have never yet been the cause of an accident. The virtues of the design lie in its great compactness. The two pairs of front-coupled wheels can be put as close together as necessary, and there are no large wheels behind to set limits to the size and disposition of the fire-box or the internal width of the cab; the small trailing wheels are conveniently placed under the fire-box, not too far from the driving wheels, and run more smoothly than coupled wheels would run. In consequence of this arrangement, these engines are remarkably little fatiguing to travel upon. With the addition of a leading bogie, this type of engine becomes the 4–4–2 type, which is now one of the favourite kinds of modern express engine. Though no very spectacular feats are generally credited to the "Gladstones," there is a legend, for the accuracy of which I do not vouch, that one of them on one occasion, many years ago, when working a light special train, passed Redhill from Brighton—nearly 30 miles—in 26 minutes from the start. Quite recently I timed one of these engines to cover 22 miles, more uphill than down, in 21 minutes 13 seconds with a load of 150 tons behind the tender.

Of late years much attention has been paid to increasing the efficiency of locomotives. From the time the water is put into the tender till the moment when it enters the cylinders as steam heat may be added to it at various stages with advantageous results, particularly if the heat employed would otherwise have gone to waste. There have, for instance, lately been built in America some very large engines, which, besides possessing boilers of enormous power, are fitted with arrangements for heating the water before it is sent into the boiler, then for superheating the steam on its way from the boiler to the high-pressure cylinders, and lastly for adding yet more heat to the steam as it passes between the high-pressure and low-pressure cylinders. If the feed-water can be heated up with exhaust steam, the result is pure gain, as the heat would otherwise have been dissipated in the atmosphere. One difficulty in the way of heating the feed-water lies in the fact that that marvellous appliance, the injector, will not work with very hot feed-water, and, in some cases, pumps have to be used instead, which are far more complicated than, and (if driven off the motion) not nearly so convenient as, injectors, which will work equally well whether the engine is standing or running. In Mr. Stroudley's time, nevertheless, the Brighton Company went in largely for heating the feed-water with exhaust steam, and secured very satisfactory results, and, at the present time, feed-water heating is coming widely into fashion. But superheating the steam is now the way in which increased economy is most generally sought, and the Brighton Railway was one of the first British companies to make experiments with superheaters. The most widely held view is that, for superheating to be really effective, quite a large amount of the heat of the fire must be diverted from the water in the boiler and applied to the steam in the superheater, so that the temperature of the steam is raised far above that at which no particle of moisture remains in it. A great deal of heat is taken from the steam on its way through the cylinders. The exhaust steam, which escapes during the return stroke of the piston, is comparatively cool, and reduces the temperature of the cylinder, which has to be heated up again by the next supply of incoming steam. In performing work, also, the steam loses an amount of heat proportional to the work done. When superheated steam is employed, there should, in theory at least, be so much heat in it that the loss of all that which is abstracted in the cylinders is not sufficient to reduce the temperature to the point where drops of water begin to form ; otherwise the steam is no longer superheated, and the useful characteristics of superheated steam are lost. As has elsewhere been remarked, the principal ones are its greater volume (a given amount of heat will produce a greater volume of superheated, than of saturated, steam at a given pressure), its greater liveliness, which makes it far more rapid in its movements than wet steam, and its low conductivity of heat, which (perhaps) causes it to give up comparatively little of the heat, which it contains, to the metal surfaces with which it comes into contact. If the steam remained superheated till after the exhaust had taken place, this extra liveliness should enable locomotives using it to attain much higher speeds than is now possible. The best designed express locomotives of the present time, working with ordinary wet steam, would probably be unable, under any circumstances, to reach a speed of more than about 100 miles an hour on the level, on account of their inability to get rid of their exhaust steam, which cannot escape rapidly enough through the exhaust passages. But superheated steam is many times more nimble in its movements than wet steam, and with it no difficulties of this kind should be encountered in reaching speeds which are to-day unheard of. Unfortunately, however, by the time the exhaust takes place, the steam, even though highly superheated to begin with, is nearly certain to be more or less wet, though it is much less wet than in an engine using saturated steam in the ordinary way.

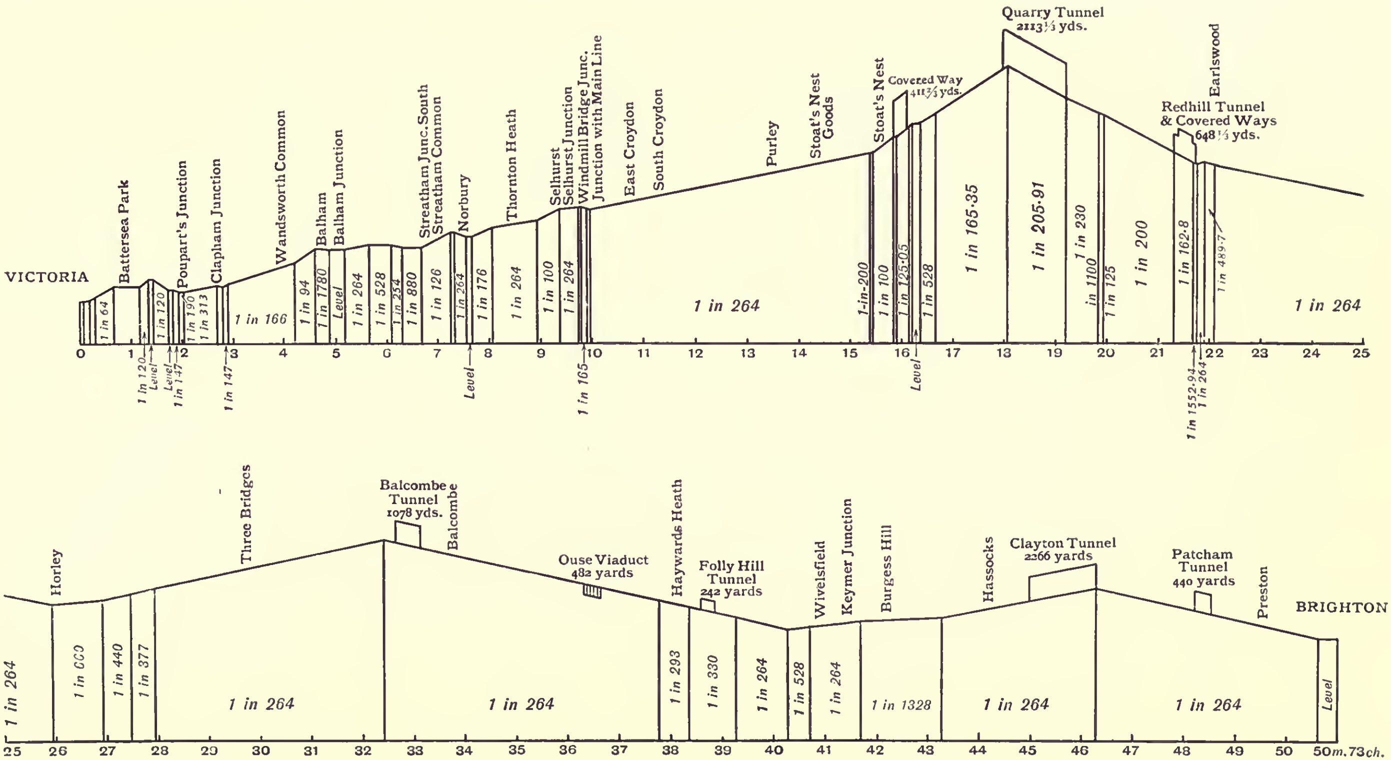
Till comparatively recent times plain flat slide valves were used on practically all British engines. These valves are very cheap, and, consisting of one part only, very simple to make, but, as they are pressed down upon their seats by a great power of steam, a great deal of force is required to overcome the frictional resistance thus set up. So long as the engine uses wet steam, the heat generated by this friction is rapidly carried off, and no further drawback ensues than a certain loss of power. Sometimes, to reduce the friction, big engines have an arrangement for preventing the steam from pressing upon more than a certain portion of the valve. With the advent of superheated steam, which is much hotter, and, at the same time, a much worse conductor of heat, than ordinary wet steam, it became necessary to use slide valves, which would move with very little friction, and piston valves, which had already been adopted to a small extent, are now generally employed in conjunction with superheated steam. These valves, as the name implies, are of cylindrical cross-section, and work in cylindrical chambers, close to the main cylinders of the engine, to and from which they allow steam to pass round their own edges. The steam presses equally all round the valve, which consequently can be made to work with only enough friction to keep it tight. As the steam is admitted and released round almost the whole of the edge of the valve, valves of quite moderate diameter give the steam very free ingress to, and egress from, the cylinders. As there is no object in keeping down the diameter of the valve below what is quite sufficient for the biggest engines, the common practice now is to have only one pattern of piston valve—generally 10 inches in diameter—for all the different kinds of engines, which are fitted with valves of this type.

After Mr. Stroudley's death the Brighton Company abandoned the front-coupled arrangement for express engines, and for some time all the new express engines built were of the orthodox 4–4–0 type. Quite lately, however, the practice of this line has again become somewhat out of the ordinary in the extensive use which is made of tank engines for working the fastest express trains. The use of tank engines has, of course, lately been extended on other lines besides the Brighton, and the increase in the size and power of such engines on many lines has been as noticeable as has been the case with express and goods engines with tenders. But for tank engines to take their turn regularly with tender engines of the most powerful type in working express trains timed at over 50 miles an hour is a condition of affairs found only on the Brighton Railway. The tank engines, which perform this work, are naturally large and powerful machines with big driving wheels, and they are fitted with superheaters. They are of two types; one is a four-coupled engine with a leading bogie and a small pair of trailing wheels, and inside cylinders; the other has six-coupled wheels and outside cylinders (4–6–2). The latter type, of which only one or two have so far been built, is very large indeed, and weighs in full working order over 85 tons. The company seems to be well satisfied with the tank engines, and has lately built a new series of the four-coupled type, but, in view of the greater all-round usefulness of six-coupled engines in general, and the very smooth and easy running of the Brighton six-coupled design in particular, it will not be surprising if the latter ends by gaining the preference. Remarkable as the tank engines are, they are, nevertheless, not the most powerful machines which the company now possesses, and, to see the Brighton Railway at its best, one must receive the permission of the authorities to accompany one of the big 4–4–2 tender engines some Sunday, when the "Southern Belle" runs between London and Brighton with seven Pullmans, all packed with passengers. One Sunday afternoon lately I was fortunate in finding No. 422 working the 5 p.m. from Brighton. This engine is one of the later lot, fitted with superheaters and enlarged cylinders—21 ins. by 26 ins.—while the boiler pressure has been reduced from 200 lbs. to 170 lbs. per square inch. Very smart did No. 422 look in her clean coat of chocolate paint, and not a few were the onlookers, who had been attracted to see her start off on her journey, for Brighton, as well it may do, takes much interest in this train. Punctually at 5 the signal was given and, without the driving wheels slipping an inch, the great engine was set in motion. The seven Pullman cars with their passengers weighed quite 300 tons, engine and tender are well over 100 more, and the

4–6–2 TANK ENGINE, BRIGHTON RAILWAY.

first $4\frac{3}{4}$ miles from Brighton to the entrance of the Clayton tunnel, where the railway burrows under the South Downs, rise continuously at 1 in 264, so we did not gather speed very quickly; but, with the regulator wide open, and steam only 5 lbs. or so below the blowing-off point, the effect of the capacious cylinders was gradually felt, and, at a constantly growing speed, we traversed the deep chalk cuttings, threaded the short Patcham tunnel, and then rushed into the obscurity of the Clayton tunnel 8 minutes 22 seconds from the start. From the southern portal of this tunnel the line begins to descend, and, with the regulator no longer wide open, but steam cut off at the same point as before, we emerged again into daylight 1 mile 506 yards further on, at a speed, which was already fairly high, and which continued to increase till over 70 miles an hour was reached at the point where the next ascent is encountered. This ascent is 8 miles long, nearly all at 1 in 264, which is the prevailing gradient upon the Brighton main line, and, except where the Ouse viaduct is crossed, a couple of miles beyond Hayward's Heath, the line is sheltered by cuttings or woods, which, on stormy days when a strong cross wind is blowing, are of much assistance; but to-day there was nothing more than a gentle following wind. Under these favourable conditions the engine made very light work of the incline, the last 6 miles to the summit, which is reached at the north end of the Balcombe tunnel taking only a second or two over 6 minutes, and this without the driver's opening the regulator wide, even as the summit was approached. The succeeding almost straight descent past Three Bridges to Horley produced a maximum speed of just over 74 miles an hour. All this time the remarkable smoothness of motion of No. 422 was most apparent. All engines with uncoupled trailing wheels are, no doubt, inclined to run smoothly, but there are often great differences in this respect between engines of precisely the same design, and in this engine the ease and smoothness of the running were quite remarkable.

Earlswood, half-way up the long bank to the Quarry tunnel summit, and 29 miles from Brighton, was passed in 31 minutes 10 seconds from the start. But here we had already slowed down, for in the Redhill tunnel, a little further on, the line was being relaid, and we had to pass through this tunnel very slowly. This loss of impetus taking place 4 miles from the top of the incline, put us back seriously, and as the line from here rises at about 1 in 200, we had naturally not fully recovered speed when we ran out of the Quarry tunnel, the third of the big tunnels which mark the three summits between Brighton and London. From here the 18 miles to Victoria are a practically continuous descent, but our troubles were not yet at an end, as, though we had reached a good speed by the time we ran on to the South Eastern line at Stoat's Nest, we shortly afterwards encountered a second severe slack where further relaying operations had lately been carried out, and the line was not sufficiently consolidated to bear trains running at the normal speed. The total loss of time involved by these two slacks amounted to about 6½ minutes, and though the line continues to fall, there were still various checks to our course, which prevented us from making much use of the favourable gradients. Beyond



PROFILE OF THE LINE BETWEEN VICTORIA AND BRIGHTON.

East Croydon, where the line for Victoria leaves the London Bridge line, our careful driver slackened speed perceptibly to run over the facing points, and then, after a moderately rapid descent as far as Clapham Junction, the brakes went on hard to reduce speed to quite a low level for passing over the very sharp curve at Poupart's Junction, where there are also facing points, and the line turns to the right on to the viaduct, which leads it to the bridge over the South Western Railway. At Poupart's Junction there were still 2 miles to go, and, with less than 2 minutes left, it was clear that we could not arrive with absolute punctuality. Indeed, we actually came to a stand at Victoria in 62 minutes 12 seconds from Brighton, instead of the hour which is allowed; but if the $6\frac{1}{2}$ minutes lost by the two permanent way slacks are deducted, less than 56 minutes are left for the run, which, without being marvellous, is certainly very respectable, work.

At the time when the South Eastern and London, Chatham and Dover Railways were separate concerns, there was no county where there were greater opportunities for railway competition than in Kent. There was hardly a place of the least importance, except Folkestone, which could not be reached by way of either of these railways, and both had secured for themselves quite exceptional facilities for reaching the very heart of London. As the district served is rich in high-class passenger traffic, and the lines are unusually free from goods trains, there was some reason for expecting that the two railways would vie with one another in maintaining an exceptionally convenient and ample passenger service. The most enthusiastic admirer of the Kentish lines could hardly assert that these expectations were fulfilled. A capital expenditure, large even in comparison with the inflated amount that all British railways have been obliged to spend, left both companies hard up for money, and unable to find so much as was desirable for maintaining their road and rolling stock at that pitch of efficiency to which we are accustomed on most of the leading British lines, while the difficulties of working lines so complicated tended to make the trains both slow and unpunctual. The mere fact that each railway had two termini in London added immensely to the complication of working the London traffic. The peculiar difficulties to which the configuration of the South Eastern line into Cannon Street and Charing Cross gave rise, can hardly be over estimated, and, if the London, Chatham, and Dover was rather better off, the necessity of dividing or joining up a great many trains at Herne Hill was a fruitful cause of delay. In this matter of their London termini the enterprise of the South Eastern and London, Chatham, and Dover Railways has probably received less than justice at the hands of the travelling public. We all of us notice and complain about the delays which sometimes occur in getting into these stations, and are apt to forget the other aspect of the question, which is that the railways confer a considerable benefit upon us by taking us across the river and setting us down in one or other of these peculiarly well situated termini, instead of landing us, as they might quite reasonably do, somewhere in the wilds of South London, and leaving us to find our own way thence. Besides the difficulty of working in and about London, there are so many places on both lines, too important to pass by, and not big enough to be served by trains run exclusively for their benefit, that the number of stops, which has to be made, prevents most of the trains from attaining any great speed. Hampered therefore, as the two railways were, by difficulties of working on the one hand, and by poverty on the other, the train service provided neither by the one nor the other met with much approbation from the public, nor did the financial results satisfy the shareholders. Under these circumstances it was decided to strike out a new line, and, as separate working had proved a failure, to see what joint working would effect. In 1899, therefore, the two railways were amalgamated for all purposes of working, the agreement which they then entered into being the first of the agreements under which, by the conclusion of alliances between two or more companies, the country is being partitioned afresh and all competition between the members of each alliance is being frankly and explicitly eliminated. To say that the amalgamation of the South Eastern and London, Chatham, and Dover Railways has been an unqualified success would be impossible. One of the first measures which the managing committee of the newly christened "South Eastern and Chatham Railway" had to take was to raise a great deal of capital to be laid out on very necessary widenings and improvements, and this expenditure, coming at a time when all railways were experiencing some diminution in their prosperity, caused the financial results of the amalgamated lines to be worse than when the two were worked separately. Neither has the pace of the trains been appreciably mended, though their punctuality has probably improved, and great convenience has been caused by the construction of junctions between the two main lines, where the South Eastern crosses the London, Chatham, and Dover, near Chislehurst, so that trains for either of these lines can start from any of the termini of the amalgamated companies. The advantage of this became very apparent, when, on December 5, 1905, a most unfortunate and expensive accident occurred, which for some time made it impossible for Charing Cross Station to be used at all. On the afternoon of that day part of the roof of that station fell in. The roof was undergoing the periodical repairs and painting, and, for this purpose, a staging had been erected, which added considerably to the weight which it had to bear. Suddenly one of the iron rods which braced the roof snapped, thereby subjecting the walls, which supported the roof, to a thrust so powerful that, before many minutes had passed, one of the walls collapsed and brought down a large part of the roof with it. The cause of the accident was a faulty weld in the rod which snapped, a flaw which it was impossible to discover and which had not prevented the rod from holding the roof securely for more than 40 years. The station had to be closed for several months while a new roof was erected, and during this time the South Eastern must have fully realised the advantage which its amalgamation with the London, Chatham, and Dover gave it in enabling it to fall back upon Victoria. The new roof, of the ridge and furrow type, gives the station quite a new and, most people think, improved appearance, though, even now, it is difficult not to regard the whole station and the bridge leading to it as a blot upon what might be one of the finest views in London. The question, which was raised in connection with the King Edward Memorial, of removing Charing Cross Station to the south side of the river, and building a new road bridge in place of the existing bridge, is full of attraction. Over a bridge of really adequate width a station south of the river would be as easy of access as the present station; much more space could probably be found for the station, which would become practically part of the South Western terminus at Waterloo; and this would enable far more useful connections than at present to be made between the trains of the two companies.

The slowness of the Continental trains to and from Dover and Folkestone is perhaps the least creditable part of the service of the South Eastern. These trains are very important, with fares probably the highest in the world, and the Tonbridge line, over which most of them run, though fairly difficult for the first 30 miles out of London, does not present any very formidable hindrances to high speed. The 4.30 p.m. put on in July, 1913, is timed to perform the run of 76½ miles from Charing Cross to Dover Pier, in 90 minutes, which is a respectable, though not a brilliant, timing, but all the other trains are slower, often considerably slower, than this. The impression created by these mediocre performances is the more unfortunate for the fact that the trains on the French side of the Channel, which run in connection with those of the South Eastern, leave less to be desired than any trains in the world. The stock of which they are made up is at least as good as that of which the British trains are composed, the speed at which they are timed is some 10 miles an hour higher, and they often make up time as well, while the fares are much lower than on the South Eastern.

To expect the little South Eastern engines to hold their own against the big new 4–6–2 engines, which the Nord has quite lately put into service, would be absurd, but, when it is remembered that the newest South Eastern engines are always hopelessly outdone by the 4–4–2 engines, which the Nord adopted in 1900, the relative inefficiency of the British company seems hardly excusable. I was once coming from Paris to London by the morning train from the Gare du Nord which was being worked by one of the 4–4–2 engines, and we were somewhat delayed on the first stage of the journey, and so left Abbeville late. The distance from Abbeville to Calais Pier is 75¾ miles, and, if we were to arrive punctually, it was necessary to cover this distance in about the same number of minutes. The line is rather a difficult one, the last 45 miles being a succession of sharp ascents and descents—it is quite as hard as the South Eastern line from London to Dover via Tonbridge—and we had very nearly 300 tons behind the tender. But without any fuss or bother the French driver swept us up the hills rather faster than usual, and when we stopped at Calais, after a start-to-stop run averaging only the smallest shade under 60 miles an hour, it appeared that we were exactly punctual. It would be interesting to hear the comments of the South Eastern drivers on a performance of this kind. I think they would be surprised at it. And yet, with a little energy and some rather bigger engines, there is absolutely no reason why trains should not run as well on the English side of the Channel as on the French. Till the South Eastern times its best trains between London and Dover in (at most) 85 minutes, and makes up time as well when the trains are late, it will not be shouldering its fair share of the burden of the London-Paris service.

If the South Eastern Continental trains are not entirely satisfactory, matters are better with regard to the cross-Channel steamers. It is true that these vessels are not so big as is desirable in the interests of the passengers in rough weather, but till the French harbours are improved there appear to be difficulties in the way of employing bigger vessels. There is no branch of engineering which is more thoroughly understood in Great Britain than the construction of swift and seaworthy steamers for channel crossings and short-distance voyages of all kinds, and the South Eastern, by its prompt appreciation of the advantages and possibilities of the steam turbine, did its best to provide vessels worthy of the importance of the service which it carries on. No steamers could, of course, perform with absolute regularity so difficult a voyage as that across the Channel, but, when the conditions are favourable, it is seldom indeed that any delay can be laid to the charge of the turbines.

Dover, being situated at the very corner of England at the nearest point to the Continent, has in some respects great natural advantages as a naval and shipping centre and a point of embarkation. But nature has provided little shelter, and the very narrowness of the Channel increases the difficulties of navigation due to the tides and winds. In order fully to utilise

Dover it was necessary to provide artificial shelter on a large scale. For many years the principal shelter was that given by the Admiralty Pier, and this was quite inadequate to make Dover a place of any great importance for shipping. But, fortunately for the South Eastern, the Admiralty realised the advantages which the position affords, and, after many years' arduous work, the enormous harbour of refuge was completed, which, enclosing as it does, about a square mile of sea, provides adequate shelter for a fleet of any size. Arrangements were, at the same time, made to enable large liners to come alongside, and Dover now possesses all the necessary qualifications for a first-class naval and shipping centre.

Now that, after innumerable announcements of the impending development of the Kent coalfield, pits have actually been sunk, and operations started, it may take very few years to effect a great change in the character of the extreme south-east corner of England, but the present is too early to found any confident hopes upon what the results of the working of Kent coal are likely to be.

Whether in years to come Dover will acquire added fame as the starting-point of a Channel tunnel cannot be foreseen, though the prospects of a tunnel have lately taken a favourable turn. If it is decided to construct a tunnel between England and France, it is almost certain that the English end of it will be quite close to Dover. This question of a tunnel is remarkably alluring to many minds, and at intervals during the last hundred years more or less elaborately thought out proposals have been brought forward for joining the two countries by this means. The geological formation of the bed of the Channel is believed to be fairly well known, and it is not thought that any very great engineering difficulties would be met with in constructing a tunnel. The enormous progress which had been made in recent years in the practical application of electricity would, of course, greatly facilitate both the construction of a tunnel and its working when constructed, and if, before electricity was available, engineers were confident of their ability to make and work a tunnel, there would now appear to be no doubt on that score, in spite of the fact that nothing of the kind on a scale in the least approaching such magnitude has ever yet been attempted. Besides the various projects for a tunnel, the construction of different kinds of bridges has been suggested; the difficulties connected with all these projects have, however, appeared on examination to be greater than those involved in the construction of a tunnel. Lastly, the idea of constructing large ferry boats, which would transport whole trains across the Channel, has found many advocates; though the ferry boats would not diminish the horrors of sea-sickness, they would certainly do away with the present intolerable inconvenience of changing into and off a boat, with the attendant scramble for places and other unpleasant incidents inseparable from these changes. Even the introduction of a service of ferry boats, however, would not be particularly easy to arrange, if for no other reason than the fact that the tides in the Channel rise and fall some 20 feet, so that the difficulties of running the trains on and off the ferry boats might be considerable. But the very serious delays and discomforts arising from the present steamboat crossings must act as a continual inducement to inventive people to find some means of doing away with them.

As regards delays, it sometimes seems extremely doubtful whether everything is done which, even under existing conditions, could be done, to minimise them. I can myself hardly remember an occasion when any train in which I have travelled between London and Dover or Folkestone has reached its destination punctually. A good deal of the unpunctuality of the up trains appears to be due to the length of time which elapses between the arrival of the steamers and the departure of the trains. As the luggage is carried in containers, which are quickly and easily transferred from the steamer to the wheels on which they run up to London, there is no particular reason why a great deal of time should be wanted for the transfer. And too often, when the train at last starts, yet more time is lost on the already slowly timed journey up to London, while it is, I believe, almost unknown for any lost time to be regained, as is almost always done on the French side if the train is late. When the Nord, as happened on one of my latest journeys, had run the two stages of 81½ miles from Calais to Amiens, and 102 miles thence to Calais Town in 86 and 108 minutes respectively, it was hardly inspiring to find the South Eastern train losing 5 minutes for no perceptible reason on the 101 minutes which it is given for the 78 miles or so from Dover Town to Victoria.

With the completion of Dover harbour, work has been begun upon a new station, to be used instead of the Admiralty Pier Station, from the inadequacy of which cross-Channel passengers have so long suffered. The new station is to be built out into the harbour on reclaimed land at the landward end of the Admiralty Pier, and, with the wide platforms and the adequate shelter which are promised, should remove what has up to now been a serious reproach upon the conduct of the Continental traffic. It is to be hoped that among other things the new station will contain a refreshment hall of adequate size, which will not be put to shame by the spacious buffet at Calais, and that the quality of the refreshments provided will equal the high standard attained by the French.

While these improvements are proceeding on the English side of the Channel, it is rumoured that the French authorities are not remaining idle. The newest turbine steamers, which have been put on the Channel services, though highly efficient vessels, are, as already remarked, rather small. It is believed that such improvements are contemplated in the harbours at Calais and Boulogne as will make it possible to employ much larger and more powerful vessels, which will be not nearly so responsive to the buffetings of the winds and waves as are those now in use. With such steamers, and with improved means of embarkation and disembarkation, it should be possible for the Paris train to leave Calais 1½ hours after the London train has reached Dover. The Nord has long been ready to run the 185 miles from Calais to Paris in 3 hours. Its new 4–6–2 engines should be capable of more than this, even with 400 tons behind the tender. The South Eastern already having a train from London to Dover in 90 minutes, Paris may, in a few years' time, be not more than 6 hours from London.

Though owing to the length of the Channel crossing, the Newhaven-Dieppe route is never likely to become a serious rival of the routes to France via Dover or Folkestone, considerable improvements have just been made on this route, and it is understood that others are about to follow. Some of the new turbine steamers are capable of performing the crossing well under 3 hours, and the French State, which has now bought up what used to be the Chemin de Fer de l'Ouest, has lately reconstructed one of the lines between Dieppe and Paris in such a manner that it will be suitable for express traffic (which was not formerly the case), thereby making available a route some 20 miles shorter than the line via Rouen. A train ferry, too, has lately been talked of for the Newhaven-Dieppe route, and it is just possible, though not very likely, that this may shortly become an accomplished fact. A service in 7 hours, or less, by this route will be one of the possibilities of the not very remote future.

The service to Berlin and elsewhere, via Flushing, is no doubt of much less value to the South Eastern than are the services to France, and, although fairly conveniently arranged, has, on the Continent, always been more of a glorified cross-country service than anything else. But there are signs that in the future the railways are going to pay more attention to this route. For some time now the night service has run by way of Folkestone, instead of Queenboro', and this, together with improvements in the trains on the Continent, has brought a good many of the big German towns appreciably nearer to London. There is no part of the world better suited than North Germany for high-speed long-distance travel, on account of the considerable distances which have to be covered, and the flatness of the country; and it looks as though the Prussian State Railways were, somewhat tardily it is true, awaking to the requirements of the situation.

It is a commonplace that the capital, which has been laid out on British lines, is much greater proportionally than that which has been laid out on any other railways in the world. The expenditure per mile of the South Eastern and Chatham has been nearly £100,000, of the London, Brighton, and South Coast about £67,000. Various reasons are given to account for the great first cost of the railways. British landowners are said to have demanded exorbitant prices for their land; legal expenses are said to have been excessive. Without being concerned to examine these allegations, which are certainly to some extent true, we must not forget, when complaint is made of the very large amount per mile which British railways have cost, that a mile of railway in Great Britain is, on an average, a much more valuable thing than a mile of railway in any other country. There is no country in the world where, in proportion to the mileage, there is so much double, and even quadruple line, and, when the cost per mile is spoken of, a mile only counts as a mile, however many lines of rails there may be running side by side of each other. British railways, again, are exceptionally well provided with rolling stock, the stations are unusually numerous, the signalling arrangements are adequate for coping with a very rapid succession of trains, sharp curves and excessively steep gradients have generally been avoided, there are few level crossings, the lines are enclosed in the most elaborate and expensive manner, and the permanent way of all the big companies is tolerable, of some really good. So, if British railways have cost a great deal (nearly £50,000 a mile on an average) to build and equip, they have, on the other hand, a very large earning capacity, and, owing to the generally high (if somewhat varying) standard of their equipment, they are, all things considered, cheap to work. The absence of anything approaching complete statistics makes it, indeed, difficult to get a very clear idea of what the results really are which the railways achieve, but there is hardly any doubt that, taking one thing with another, they give their customers more for their money than do those of any other country.

Railways, whose capital expenditure has been small, may achieve good results on a small volume of traffic economically conducted, but, for British railways, which have spent so much capital, and have been built to cope with traffic on a large scale, to have any chance of paying well, it is essential that their turnover should be very large. This being so, it often appears as though too much attention were given to keeping down the ratio of working expenses to gross receipts, while not enough was devoted to endeavouring to secure the highest possible ratio of net receipts to paid up capital. The ratio of working expenses to gross receipts is, on most British lines, something over 60 per cent., and varies comparatively little between one line and another. Yet some lines pay much better than others, since this ratio is the result of turnovers widely different in proportion to the capital involved.

Thick as the traffic already is in Great Britain, there are few existing lines which could not accommodate a great deal more than they actually do accommodate, and, if a considerably increased volume of traffic could be secured, it would not matter if the ratio of working expenses to gross receipts did go up. A turnover of £1,200,000, with working expenses at 70 per cent., produces the same profit as a turnover of £1,000,000, with working expenses at 64 per cent. Under ordinary circumstances, moreover, the greater the total volume of traffic, the cheaper it is to work. In many places, where existing lines are capable of carrying more traffic than they now have to deal with, it might be very well worth while reducing charges and spending money in giving increased facilities in order to secure a greater turnover.

The theory of the financing of public companies, like railway companies, is that the capital consists partly of debentures (which are technically loans) and partly of shares. The debenture-holders receive interest at a fixed rate upon their holdings, and, so long as this is forthcoming, are not entitled to interfere in any way in the management of the company, which is the property of the holders of the shares. Ordinary shares are moderately speculative investments, and, as such, sometimes fail to satisfy either those persons, who desire above all things a regular return upon their money, or those who desire shares, the value of which may fluctuate sharply. Under these circumstances a practice arose of dividing each ordinary share into two parts, one of which (preferred ordinary share) was to receive the whole of the dividend due upon the undivided share up to so or so much per cent., and the other (deferred ordinary share) anything that might be available beyond the dividend upon the preferred share. The stability of the preferred share was thus assimilated to that of debentures, while most of the speculativeness attached to the undivided shares was transferred, and in a higher degree, to the deferred shares. An objection to stock splitting from the point of view of the welfare of the company is that, if the value of the deferred shares falls very low, it is possible for any one, by the investment of a comparatively small amount of capital in these shares to acquire a disproportionately large measure of the controlling influence, which the voting power attached to these deferred shares confers on their possessor; but the risk of this is considerably diminished by the fact that it is always arranged that the holder of a large block of shares has proportionately much fewer votes than would attach to the same holding distributed among a number of small investors.

In the case of most British railways the nominal capital represents shares which have been paid for, or issued in return for some sort of valuable consideration, but, in a few cases, notably that of the Midland, the capital has nominally been largely increased (under Parliamentary sanction) by dividing £100 shares into two parts, and calling each of the parts a £100 share, or by carrying out some analogous financial operation. There can, of course, be no secrecy or illegality in any of these transactions, but nevertheless, complaints are sometimes made of them on the score that they tend to obscure the real financial position of a company and give it an opportunity of pretending that it is less prosperous than is in fact the case.

The interest which the great body of railway proprietors take in the railways, in which they hold shares, is probably confined to the dividends which they receive, and to the prices which their holdings will fetch on the Stock Exchange. It must be confessed that any shareholder desiring to interest himself beyond this point in his railway has not, up to the present time, enjoyed great facilities for so doing. Beyond the dividends and the very perfunctory figures given in the published reports, there are, or have been up to now, almost no means of judging of the success or otherwise of a railway's policy. In consequence of the new Act of Parliament dealing with railway companies' accounts more detailed information will be available in future.

The Great Eastern Railway, though in the happy position of having its own district largely to itself, has certain disadvantages to cope with, which make it a difficult line to work satisfactorily. It has a large suburban traffic into London in the morning and out of London at night, almost all of which, in either direction, has to be accommodated within a comparatively short space of time, it serves no provincial towns of first-rate importance, and there is a complicated network of cross-country lines, with small traffic, to be provided for; the suburban traffic is conducted at extremely low fares, though its existence has necessitated a large expenditure of money to provide the requisite accommodation, both as regards running lines and terminal facilities; owing to the absence of any very large centre of population besides London, the company has nowhere a steady flow of really profitable traffic—passenger or goods—to make up for the low receipts of the numerous single lines across country, and in consequence of the railway's running through the East End of London and the works being situated there, the Great Eastern suffers severely from the exactions of the local authorities where the rates have reached the highest level.

For a good many years the railways have raised a bitter cry against the local taxation which they are called upon to bear. Time after time at the General Meetings have the Chairmen drawn attention to the enormous sums which the railways have each year to pay away in rates, and innumerable instances have been given of cases in which the payments exacted from the railways in various localities are excessive to the point of being grotesque. That the present manner of rating railways leaves much to be desired is certain, though it is doubtless by no means the only particular in which the British rating system is defective. It is a question whether railways ought to be made to contribute to local taxation at all. They are, in the fullest sense of the term, national necessities—necessary for all parts of the country, and for practically every member of the population. Any tax levied upon railways is indirectly a tax upon travel and transport, and, if levied at all, should certainly be levied by the Government, and in such a manner as to bear equally on all railways, and to benefit all parts of the country equally. But what actually happens is that the various local authorities levy rates upon the railways (according to the excessive rateable value assigned to them) very much as they do upon other property lying within their districts; in some places the rates are much higher than in others, and in some the rateable value of the railways is much greater, in proportion to the total rateable value, than it is in others. Local rates levied upon railways being, as already remarked, an indirect tax upon travel and transport, to which every one must contribute, those places where much railway line exists, and where the rates are high, are unfairly favoured as against those where little railway line exists and the rates are low, which not only receive comparatively little contribution from the railways to their expenditure, but also get less railway facilities.

The rates which the railways have to pay form so large a part of the total local revenue of the country that it would be extremely difficult to dispense with them. Otherwise the fairest arrangement would probably be to excuse the railways from paying rates at all, and to arrange that they should make a corresponding reduction in their charges. Failing this, some definite proportion of the gross or net earnings of the railways might be collected by the Revenue Authorities, and distributed to the different local authorities, proportionally to the population of their districts. Unfortunately, so many people, including influential shareholders in, and customers of, the railways, appear to find the power of the local authorities to levy heavy rates upon the railway companies so very convenient to themselves that it would be extremely difficult to rouse any strong public feeling against the existing system, in spite of the abuses to which it gives rise.

Railways have almost all come to the conclusion that their short-distance suburban passenger traffic is more trouble than it is worth. Such lines as they possess they must continue to work, and work to the best advantage they can, but only under very exceptional circumstances do the railways now seek to extend the field of their suburban operations. The Great Eastern, therefore, though making the best of a bad job, and bringing to bear much resource towards solving the different problems which are constantly presenting themselves owing to the growth of the suburbs which it serves, probably does not regard its suburban traffic with any enthusiasm. But, enthusiastic or not, it has to provide transport for the densely packed masses of people which populate the urban and suburban districts through which its lines pass, and make the total of passengers travelling by the Great Eastern each year greater than the numbers transported by any other company. The quickest possible succession of trains as long as the platforms will take, composed of carriages seating six a side, is at some times of the day barely sufficient for the crowds of people, who use the line. But when all is said and done the Great Eastern would probably be quite as well off if it had never carried a single suburban passenger. Far more profitable must be the considerable number of season-ticket holders who, living in the country, outside the suburban area, are constantly travelling to and from their places of business in the City, to which the Great Eastern, landing them at Liverpool Street, gives the readiest possible means of access. It would be interesting to take a poll of the City men, who live out of London, and ascertain how many make use of the Great Eastern for getting up and down, as compared with the numbers who live on other systems. The clients of the Great Eastern would certainly make a goodly showing.

Liverpool Street, although conveniently situated for City passengers, is disadvantageously placed for the purposes of most other people. It is a long way from the chief residential districts, and it is often very difficult of access, both on account of the congestion of the narrow streets of the City, and of the small space available for vehicles in the yard of the station itself. The Underground Railway, too, reaches it by a route which is very circuitous. Under these circumstances it is not surprising that the Great Eastern gave the Central London Tube every encouragement to carry on its line to Liverpool Street. The extension of this tube to Liverpool Street has provided a rapid and easy means of access from the best part of London, which is bound to have a most favourable influence on the passenger traffic of the Great Eastern, and, by making it easy for people to reach Liverpool Street below ground, will no doubt encourage them to send their luggage on ahead, and avoid suffering from, and adding to, the congestion of the streets, which, in early August and at other busy times of the year, makes the approach to Liverpool Street in any kind of road vehicle an experience from which the hardiest are inclined to shrink.

The most profitable part of the Great Eastern's passenger traffic is the summer traffic to and from the numerous seaside places on the system. To realise the importance which the Great Eastern attaches to Cromer and Yarmouth at this time of year, it is only necessary to compare the summer train service to these places with that provided during the rest of the year. Cromer and Yarmouth are both of them served by trains run specially for the summer visitors;

and performing the journey in half an hour less time than the best winter trains, the Yarmouth train not stopping at all *en route*, and the Cromer train stopping only at North Walsham. It is apparently for these summer trains alone that the Great Eastern has laid down its water troughs, for during the rest of the year there is no train that runs more than about 70 miles without stopping. Though Cromer and Yarmouth are the most important of the Great Eastern's seaside places, there must be nearly a score of others, all of which are given carefully planned connections with London, and contribute very sensibly to the receipts of the railway.

All this seaside traffic being almost entirely third-class traffic, it sometimes happens that such first-class passengers as there may be do not receive all the consideration they would like. One Sunday not long ago the evening express from Cromer, so far as a hasty inspection could reveal, was entirely made up of dining-cars and third-class bogie carriages of the latest pattern, except for the solitary first-class carriage in the train; this was a 6-wheeler, and one of those in which the economically-minded designer has, by rearranging or omitting the usual arm-rests, endeavoured to cram an extra person into each side. To have paid a considerable number of shillings beyond the third-class fare to obtain the privilege of travelling in this vehicle, exactly above one of the axles which hammered heavily over the rail-joints, is an investment which I cannot help regretting.

If in 1911 the losses caused by the railway strike were off-set by the remarkably fine weather of that summer, there was in 1912 no similar compensation in the summer for the losses due to the coal strike, which took place in the spring. Very heavy and continuous rains throughout August deterred people from going away from home, ruined a great part of the harvest, and in many parts of the country actually finished by rendering the railway lines impassable and causing the complete suspension of traffic. No railway suffered more severely than the Great Eastern. East Anglia, usually the driest part of England, was visited by an abnormal succession of heavy rains, culminating on the 26th of August in a downpour which, in the neighbourhood of Norwich, amounted to 6 inches or a little more in the course of 12 hours. In consequence of this a great many of the railway lines were flooded, and some actually washed away, and Norwich itself for a short time could not be reached by rail at all. The damage to the railway lines was so serious that it was many days before some of them could be reopened, and during all this time the Great Eastern was losing a great part of its holiday traffic, upon which it is more dependent than perhaps any other British company.

Norwich is much the biggest town, of which the Great Eastern gets the whole passenger traffic to and from London. It is, too, much the largest town in East Anglia, and, as it is only 115 miles from London, by the shorter route via Colchester, it must be capable of providing, at some convenient hour, a full train-load of passengers in each direction daily. As it is, it cannot be said that Norwich is well treated; except for one down train (to Norwich, Trowse, 114 miles), from July to September inclusive, there is no train which performs the journey without a stop, and most of the trains stop so often that they can hardly be regarded as expresses at all. Except for one or two extra trains on certain days of the week, there is for the greater part of the year only one train in either direction which takes appreciably less than 3 hours over the journey, and there are none at all in so little as 2½ hours. The Chairman of the Company told the shareholders a few years ago that the permanent way was rapidly being brought to a condition of great perfection, which condition is presumably already attained on the principal main lines; and, although there are four or five places where certain reductions of speed must be made for purposes of safety, it would be quite possible for one of the ordinary 4–4–0 engines to run a train weighing (exclusive of engine and tender) 180 tons or so in either direction between Norwich (Thorpe) and Liverpool Street in the even 2 hours.* This is one of those improvements which are crying aloud to be made on almost all the railways in Great Britain. Everything is ready for great accelerations—the road, the signals, the engines, the brakes, the carriages, and the people to fill them. Of the benefit to the public, which a great reduction in the time spent in travelling would bring, there can be no doubt.

The Continental service of the Great Eastern, in so far as it competes with that of the South Eastern, is handicapped, as regards London passengers, by the fact that Victoria is for most people much more accessible than Liverpool Street. But, though the Great

* One day, a year or two ago, No. 1813, a 4–4–0, ran from Norwich (Thorpe) to Ipswich (46¼ miles) start-to-stop, in 50 minutes, with a train of quite 200 tons. If the train had not stopped at Ipswich, the time of passing would have been about 49 minutes from the start, or not more than 3 minutes behind the timing, which a 2-hours' run to Liverpool Street would necessitate.

Eastern takes a great deal of pains to attract passengers to and from London, it probably relies more upon those from the north of England and the Midlands, for whom it runs through carriages to Harwich from many of the most important towns.

Though the best friend of the Great Eastern could not describe its trains as fast, the line has earned a very good reputation for punctuality. There is no virtue in railway management which makes a better impression on the travelling public, or gives the railway practising it a better name. Punctuality is one of the few things about which there is doubt. A passenger knows beforehand how much his ticket will cost and what sort of accommodation he will get, and does not trouble himself with anxious thought on these matters. But the fear of unpunctuality, of missing a connection, or arriving late for an appointment, is a constant source of annoyance, and a railway which relieves its customers of these apprehensions does perhaps more to win their approbation than could be done in any other way. Punctuality, too, has very important effects, which directly benefit the railway company, altogether apart from the sentiments of the passengers. Most important railway lines are more or less crowded with traffic, and very elaborate schemes have to be drawn up for getting the trains along. Each train has just its few allotted minutes for travelling over each section of the line, and, when they have elapsed, it is the next train's turn, and so on. If the proper train is not there at the proper time the scheme of working can no longer be carried out, and a greater or less degree of confusion results. It wants comparatively little unpunctuality to bring about a considerable degree of confusion, for, if only one train is out of its place its lateness may affect the working of scores of others—those following it, those crossing its path, those connecting with it, and those whose running is affected by the lateness of those delayed by it. And unpunctuality is not economical. So small a thing as an extra signal stop is an appreciable expense—so much energy is dissipated and has to be generated afresh by the engine, and there is so much extra wear and tear of the brake blocks and tires. Then, if there is unpunctuality, the work of the whole staff of the railway, which has to deal with the trains affected, is delayed, and has to be done at a time different from that at which it ought to be done, and perhaps the additional cost is incurred of paying men for working overtime.

Punctuality has so much to recommend it that it is strange that greater pains are not taken to ensure that the greatest possible measure of it shall be achieved. Perfect punctuality is no doubt unattainable, but it is quite possible to attain a very high degree of punctuality; and the means of attaining it are, firstly, so far as possible to eliminate delays, and, secondly, when delays occur, to make up the time lost. It may be assumed that the elimination of delays already receives all due attention, but the question of making up lost time is not so satisfactorily taken in hand. The question has unfortunately got mixed up with that of excessive speed, from which it is really quite distinct. The facts as regards excessive speed are these: there are certain places, particularly curves, where it is dangerous for any train to run at more than a certain speed, lest it should come off the rails, there are some classes of engines which, owing to their construction, are unsuited for running at more than a certain speed, either at all, or in places where other classes of engine might run at any speed, and there are certain lines, which are not of sufficiently solid construction safely to carry trains running at more than a certain speed. But the safe limits can in every case be accurately determined, and, if these limits are respected, such a thing as excessive speed does not exist. Suitably constructed rolling stock, running over a strongly built line, without sharp curves, is in no danger of leaving the rails at any speed which can be attained, and, subject to a strict observance of the limits indicated above (which in point of fact are seldom great enough or numerous enough to constitute a serious hindrance) trains could exceed their booked speed to any extent without any danger whatever. It may, of course, happen that the engine is not powerful enough to put forth the extra effort required for making up time, in which case nothing can be done, but whenever she is powerful enough there is every reason for making up as much lost time as possible, so as to reduce as far as possible the annoyance caused to the passengers and the subsequent disorganisation of the traffic. It must also be remembered that, although accidents on British railways are, in any case, very rare, they are distinctly less likely to happen when the traffic is being worked as nearly as possible in accordance with the time-table, so that the making up of lost time tends towards greater safety.

At one time the Great Eastern had a good many engines which burned liquid fuel on a system introduced by the company. The apparatus worked with great success, but the enormous increase in the demand for oil which has taken place of late years has raised the price in Great Britain to such a point that oil is now too expensive to be used in locomotives.*

One of the objections to the introduction of very big engines is that when the grate reaches a certain size it is more than one man can do to supply it with coal when the engine is working hard. In this country grates have hardly yet reached these dimensions. The comparatively good coal which British engines burn often enables them to do the same amount of work as engines in other countries do which have grates 50 or 100 per cent bigger. But the question of reducing the work demanded of the fireman is bound to come more and more to the front. If oil were not so expensive, the problem could be solved completely and easily by the use of liquid fuel, but unfortunately this is not now possible, except in those parts of the world where oil is produced in bulk. No greater contrast could be imagined than there is between the continuous and exacting work of a fireman on a big coal-burning engine and the almost complete leisure of the same functionary on an oil burner. The former, in extreme cases, has hardly time to mop the perspiration from his brow after throwing one charge upon the fire before it is time for him to begin putting on the next, while the latter regulates the production of steam from nothing at all to the greatest effort of which the largest engine is capable by turning a handle which is conveniently arranged in front of him as he sits at his ease. The problem of automatically supplying

* The Great Eastern may still have a few oil-burning engines, but has not many, I imagine.

the furnace with solid fuel is, of course, one of much greater difficulty. Indeed, it seems doubtful whether it will ever be possible altogether to dispense with the fireman's shovel. In the first installations, at least, it is more probable that a certain proportion of the fuel will be introduced automatically into the fire-box, and the fireman left to complete the supply in the ordinary way. An apparatus working on these lines has already been tried. Continuous streams of little briquettes about the size of lawn tennis balls are blown by steam jets into the fire-box, through pipes of suitable size, which enter the fire-box on either side of the door. The matter is, however, for the present very much at an experimental stage.

One of the simplifications in locomotive design, to which most British engineers cling, is the blast-pipe with a fixed orifice. To make an engine run freely the orifice of the blast-pipe must be as large as possible, so as to give the exhaust steam the easiest possible exit from the cylinders. Sometimes the engine can make steam with a larger blast-pipe orifice than is at other times necessary; but, unless the blast-pipe has an orifice whose section can be varied at will, it is necessary to have the orifice small enough to make steam under all conditions. British engines, with fixed blast-pipe orifices, must, therefore, frequently suffer from a slightly higher back-pressure in the cylinders than is absolutely necessary. Many foreign engines are made with blast-pipes, the diameter of whose orifices can be varied at will by the driver. Of course, there is always the danger that the driver will avail himself in the wrong way of his power to vary the size of the orifice, and will keep it unnecessarily small, in which case the variable blast-pipe will prove an actual drawback. This appears to be a chief reason why variable blast-pipes are so little used in England. Some British engines, however, particularly on the Great Eastern, have blast-pipes with a rather large orifice, to which, by the movement of a lever, a cap with a smaller orifice can be fitted.

It is interesting to look towards the future and endeavour to decide whether railways are likely to be an enduring phenomenon or whether, when they have served their turn, they are likely to be displaced by some more perfect method of transport. The essential advantage of a railway is that it provides a means whereby vehicles can be moved with an extremely small expenditure of power in comparison with their weight, and this is due to the hard and smooth surface offered by the rails. It is safe to say that no means will ever be discovered which will present any advantage worth mentioning over a railway in this respect. In addition to the advantage of the very small amount of power required to move the vehicles, a railway offers the further very great advantage of complete control over the direction of movement—the vehicles cannot deviate from the line of the rails and no steering is necessary. It may be assumed, therefore, that no system of transport can ever be much cheaper to work than is a railway. The only kind of system which could possibly compete with railways would be one which was much cheaper in first cost.

There are three possible media by which transport can be carried on—land, water, and air. While it is perhaps not impossible that some form of single rail arrangement, worked by rolling stock swung below it, or kept upright above it by means of gyroscopes, might be much cheaper to build than an ordinary railway, especially in mountainous regions, it is most improbable that any such arrangement would offer advantages which would make it worth while adopting it generally in any country already well supplied with railways of the ordinary kind ; and, even so, it would merely be replacing one kind of railway by another. Some kind of automatic guiding seems absolutely essential for land transport carried on in bulk ; as this is very well supplied by rails, it seems hardly possible that rails will ever be dispensed with ; and, in view of the very great efficiency and safety of the ordinary system, it is difficult to see how this system could ever be exchanged for another.

Water transport possesses, of course, under favourable circumstances, advantages with which railways cannot compete. Where nature supplies the waterway, the first cost involves nothing but the provision of boats and landing-stages. Water transport is, and was from remotest antiquity recognised to be, the most natural means of transport, and this gave it a long start of railways ; and the construction of canals, and the deepening of the courses of rivers, the natural developments of water transport, were available for facilitating such transport long before railways came into existence. In spite of this, railways had in most cases no difficulty in catching up and out-distancing the inland waterways as avenues of traffic, and even the Royal Commission on canals, who desire to see a development of the British canal system, do not venture to suggest that this could be carried out without a State guarantee. Under these circumstances, it hardly looks as though railways were in much danger of being permanently superseded by any method of inland transport by water.

There remains the possibility of the development of air transport. As with sea transport, the first cost would be confined to providing the vehicles and landing-stages, and great possibilities of economy present themselves. But the many obvious difficulties in the way of carrying on a large, regular, and frequent traffic by way of the air need not be enlarged upon, and the possibility of effective competition with railways by means of air vessels is probably as remote now as it was before the remarkable feats of the airmen had begun to take place, to which we are getting accustomed.

So far, then, as it is possible to look ahead, there seems little likelihood of railways losing their importance. As time goes by no doubt more and more perfect methods of moving and controlling trains will be evolved, but as far as the actual railways are concerned, there is a good prospect of their usefulness continuing for centuries.

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THE END

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